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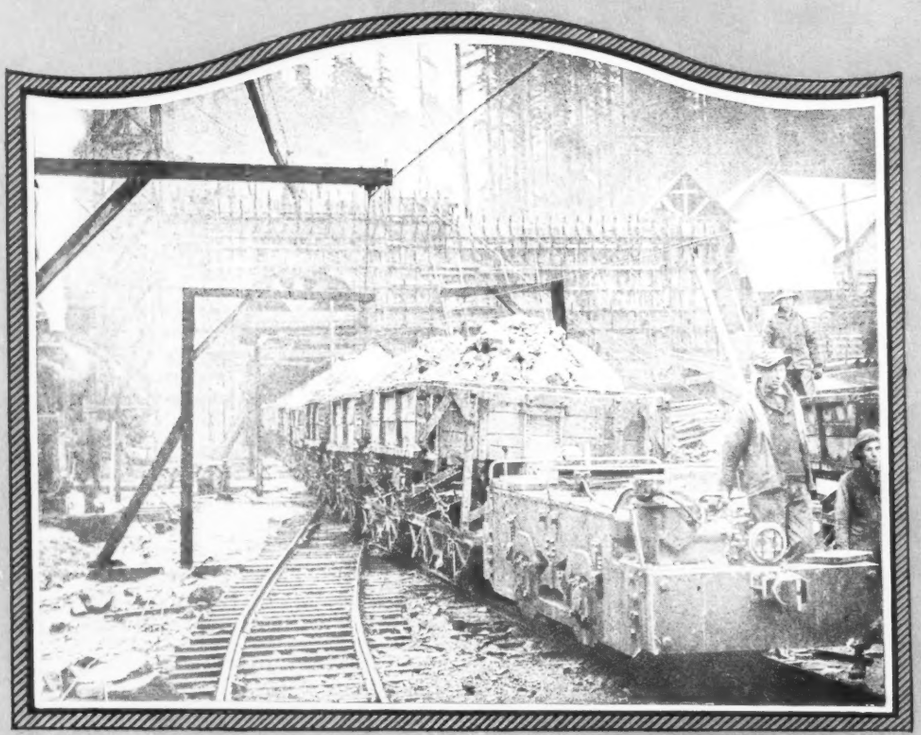

WEST PORTAL OF THE NEW TUNNEL NOW BEING DRIVEN THROUGH THE CASCADE MOUNTAINS BY THE GREAT NORTHERN RAILROAD

Savings Effected By Oil-Engine Compressor
G. P. Proctor

Hydro-Electric Plant Built in Ausable Chasm
A. S. Taylor

Great Northern Railway Driving Long Tunnel
R. G. Skerrett

Homes Built of Rammed Earth
C. H. Vivian

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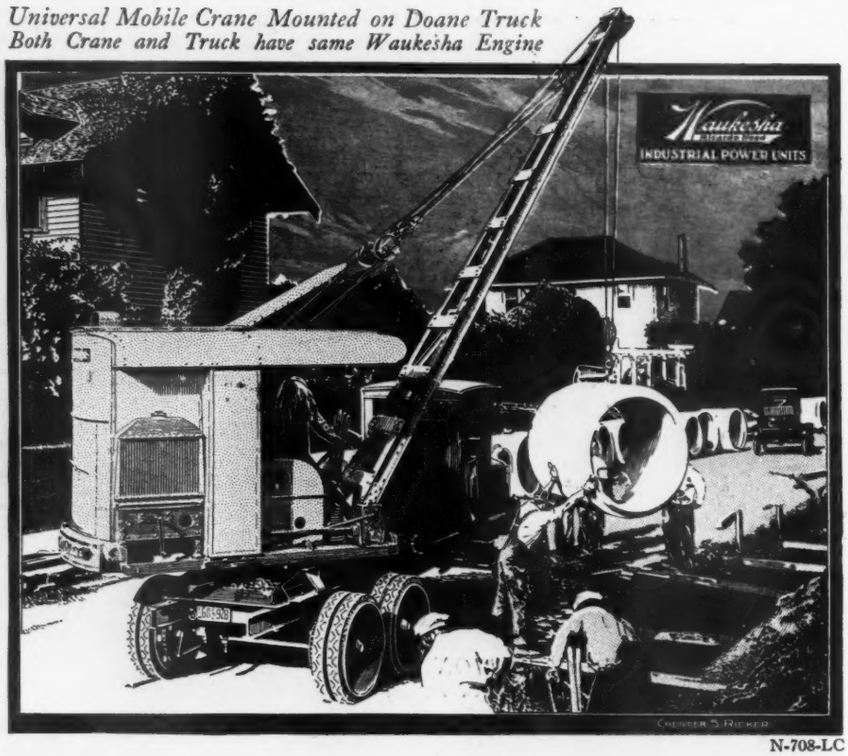
Universal Mobile Crane Mounted on Doane Truck
Both Crane and Truck have same Waukesha Engine



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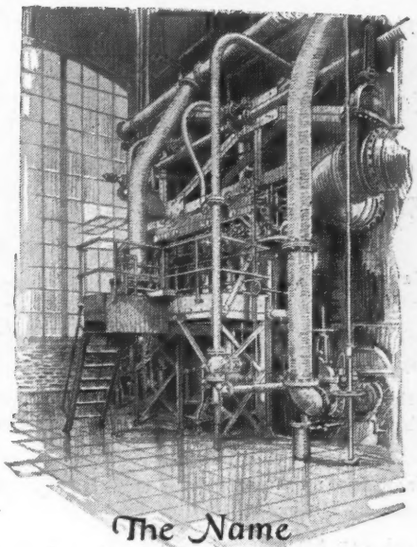
TRADE MARK



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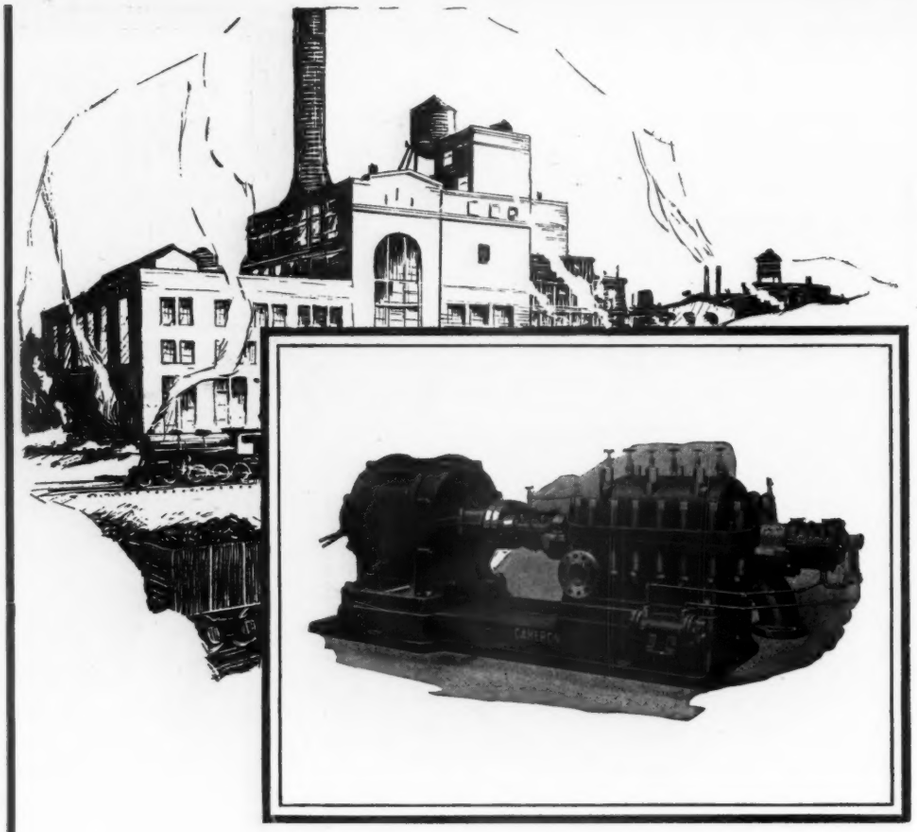

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Great Northern Railway Driving Long Tunnel Through Cascade Range

This Notable Undertaking Will Involve An Ultimate Outlay of About Ten Million Dollars

PART I

By ROBERT G. SKERRETT

ONCE more, the Great Northern Railway is putting through an amazing engineering undertaking. That enterprising road is driving a tunnel 7.79 miles long through the heart of the Cascade Range in order that its trains may move more rapidly in a region where heavy snows are common in the winter months. This is the present climax of a battle with Nature that began in the early "nineties" after John F. Stevens discovered the mountain pass that now bears his name.

No phase in the splendid history of the Great Northern Railway is more spectacular than the course pursued by its first guiding genius, James J. Hill, in taking the line across the snow-capped Cascade Range in order that the vast wheat fields of our "Inland Empire" might be linked with an outlet to the Pacific through the Port of Seattle. Conversely, the desire was that Seattle might enjoy the benefits of ampler rail connections with the whole hinterland of the nation east of that formidable mountain barrier which had for many years hampered the city's logical expansion.

When the Great Northern, in its efforts to serve, determined to carry its rails over Stevens Pass, the only solution at the time lay in building a complicated series of switchback tracks—three legs of which were on the east side of the summit and five legs were on the west side. For eight years after the line was opened, trains had to climb 677 feet higher than they now do. In addition to that, it was necessary to construct a long and tortuous way down the west slope immediately below the pass to the station at Scenic where the Tye River and Surprise Creek meet.

THE Great Northern Railway is now engaged in driving through the Cascade Range, in the State of Washington, the longest railroad tunnel so far undertaken in the United States. It will be 7.79 miles in length between portals, and will be the means of saving much time for trains bound east and west by that route.

To the engineer and to the contractor, the work is of outstanding interest owing to the nature of the ground penetrated and because of the facilities used to carry the job forward with all practicable dispatch. Progress records have already been broken on several occasions.

The ultimate purpose of the tunnel is to enable the railroad to serve still better a vast territory which it already serves well.

The road came through the pass in 1892; and on January 6, the year following, the last spike—a gold one—was driven at a point between Scenic and Alpine where the section coming east from Everett met the section coming west over the Cascade. The first train to enter Seattle upon the completion of the work did so in the summer of 1893; and then and there began a new and wonderful period of growth for the Queen City of the Pacific Northwest.

Seattle is, indeed, a surprise city; and no single agency has contributed more to her amazing development than the Great Northern Railway. Before the Great Northern entered Seattle the city was inadequately supplied with railroad facilities. Geographically, Seattle enjoys an ideal position in relation to seaborne commerce with the principal ports of the Orient and Alaska and the Pacific ports generally of both North and South America; and she is favored with an ice-free harbor the year round. Furthermore, Seattle lies at the gateway of a state blessed with enormous natural riches. But, despite these advantages, Seattle was crippled for years by her lack of railroad connections; and her development was slow until sometime in the "nineties."

Perhaps the story of Seattle's astonishing social, financial, and industrial expansion can best be made manifest if we cite a few outstanding statistics. In 1858, Seattle had a population of 150 persons; and it was not until 1900 that her dwellers numbered 80,671. Today, according to competent authorities, she has within her immediate limits and in contiguous suburban communities a total of more than 400,000 persons. So much for the social change wrought for the most part within a span of only twenty-five years.

As recently as 1890, the banks of the city held in the form of deposits an aggregate of but $1,800,000. In 1925, the deposits totaled more than $192,202,000. Factories in Seattle now turn out annually products worth $200,000,000; and manufacturing is of a diversified character. Seattle's wonderful position as a port of entry and a port of departure may properly be considered her prime business as-

Pickett Photo Company.

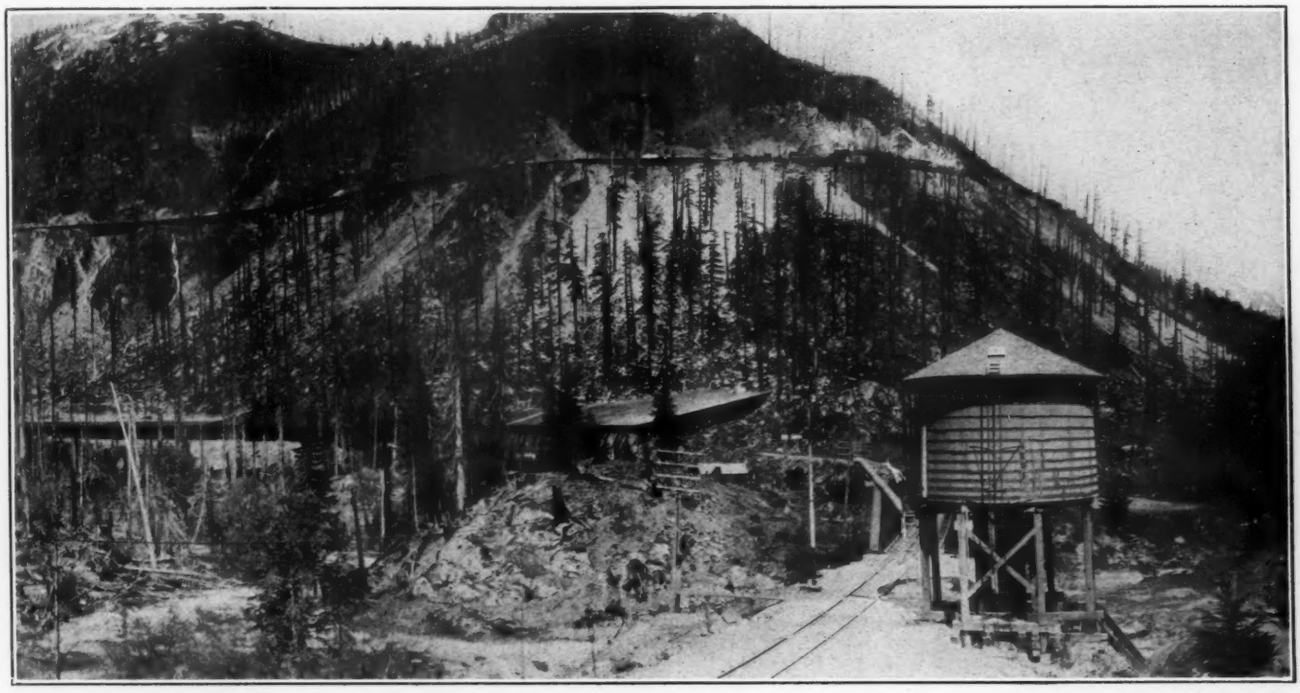
From the station at Scenic, at the extreme left, the line climbs the neighboring mountainside by a series of sharp curves and a stiff gradient until the crest of the ascent is reached more than 500 feet higher up.

set; and this is confirmed by reliable figures. The port handled in the course of 1925 more than 7,847,500 tons of water-borne commerce; and the commodities involved had an aggregate value of quite $730,669,000. Needless to remark, the vast bulk of this freight was dispatched overland, to or from Seattle, by rail—emphasizing to that extent the vital part played by the trunk lines in promoting the city's notable prosperity.

For eight years following the opening of the route over Stevens Pass, the Great Northern labored at a serious disadvantage—especially so in the wintertime. Therefore, it began in 1897 to drive a 2.63-mile tunnel through the range at a lower level. This tunnel—known as the Cascade Tunnel—extends from Cascade Tunnel Station, at an elevation of 3,382 feet, to Tye which lies 234 feet below on the west slope of the mountain. The tunnel was ready for service in 1901, and promptly effected a saving of substantially two hours in the run between Berne on the east and Scenic on the west side of the pass.

Even with this improvement, costing about $3,500,000, there still remained a number of physical difficulties that have added heavily since to upkeep and operating charges on the division mentioned. In the run eastward and upward from Scenic to Tye, during which Martin Creek is crossed twice, the 2.2 per cent. climb has numerous sharp turns, and there is an aggregate curvature of 2,128 degrees before Berne is reached. That is to say, a locomotive with its trailing load makes the equivalent of nearly six complete circles before finishing its run over the pass. The meaning of this can be even more readily grasped if we mention that the distance by air line between Scenic and Berne is 9.99 miles while by rail it is 17.67 miles! It takes a passenger train an hour and ten minutes to make the journey from

1—The station at Scenic with one of the portable compressors used in the early stages of work at the West Portal.
2—Large side-dump cars that handle muck in enlarging the main tunnel at the West Portal.
3—All hauling in the tunnel is done with electric locomotives.
4—Mr. M. J. C. Andrews, resident railroad engineer, and one of the survey stations used in verifying the tunnel line.



Pickett Photo Company.

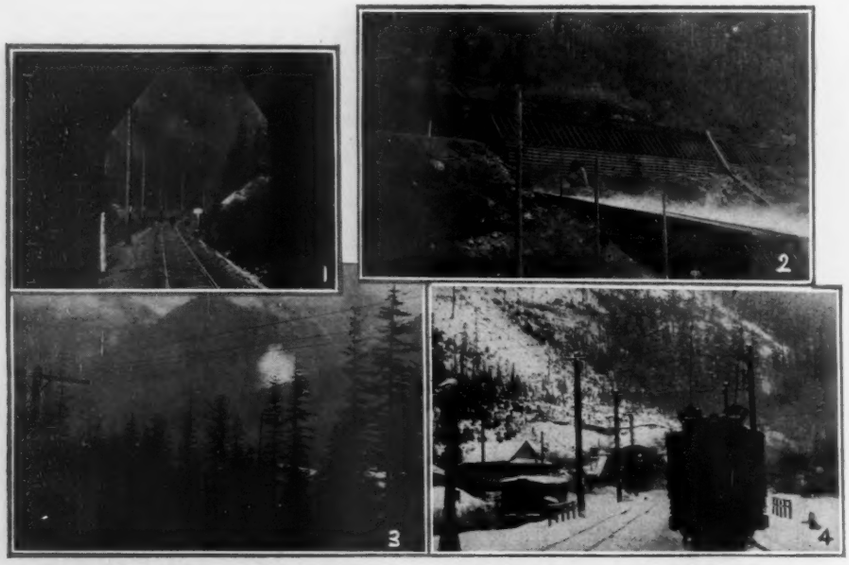
This long, tortuous, and steep section of the road will be avoided when the tunnel now building is completed. This panoramic photograph shows the tracks at three different levels of the climb over Stevens Pass.

Scenic to Berne, while a freight train requires double that time.

Heavy freights, eastbound from Seattle, are now pulled by a single powerful steam locomotive to Skykomish, 12 miles below and west of Scenic. At Skykomish, two helpers are added—one of these engines is placed in the middle of the train and the other acts as a pusher at the rear end. In this way, trains of seventy cars—representing a 2,700-ton load—are slowly moved up the climb to the west portal of the existing Cascade Tunnel. At that point from two to three electric locomotives take the train through the tunnel; but the electric locomotives generally require the help of one of the steam locomotives to get the train started again. So much for the tractive difficulties incident to mounting the long and winding 2.2 per cent. gradient.

Bad as conditions are, because of the gradient, matters are made worse from a maintenance standpoint by the upkeep of the snowsheds that have been built along this troublesome part of the line to shelter trains from the destructive sweep of snow slides. Some of these snowsheds are constructed of concrete and others of massive timber—for all practical purposes they are virtually tunnels. They represent a very large initial outlay; and their upkeep necessitates an expenditure each year of from $300,000 to $400,000. To this sum must be added the cost of snow service requiring the use of powerful rotary plows, etc.

1—Portal of Horseshoe Tunnel where the line makes a sharp turn in crossing Martin Creek.
2—Residences of superivising officials at the West Portal Camp.
3—Loading a powder car with dynamite at the West Portal.
4—A heavy freight train leaving Scenic on the stiff climb over Stevens Pass.



1—Vista looking out from one of the snowsheds on the climb between Scenic and Cascade Tunnel Station.
2—Snowsheds at two levels on the west side of Stevens Pass.
3—A bit of mountain scenery on the line above Scenic.
4—Cascade Tunnel Station with the east portal of the present tunnel in the background.

This service, depending upon the severity of the season, entails an outlay of from $40,000 to $60,000 annually. These facts are cited merely that the reader may have some understanding of the burden that the Great Northern Railway has borne in its tireless efforts to give satisfaction to its shippers—large and small—and to the thousands of passengers using this wonderful scenic route to and from the Pacific Coast.

With a desire to achieve substantial operating economies and, at the same time, to insure a speedier run through the Cascade Range, the alert management of the Great Northern Railway decided the latter part of 1925 to connect Scenic and Berne by a single tunnel, nearly 8 miles long, that would have a grade of 1.565 per cent. and would obviate a combined climb and descent of approximately 1,000 feet—the difference in climb between the existing tunnel line and the new tunnel line being 501 feet. For the sake of those interested in details, a table is inserted showing the main features of the present and the new routes.

COMPARATIVE FEATURES OF PRESENT AND NEW LINES BETWEEN BERNE AND SCENIC

	Old Line.	New Line.	Favorable To New Line
Length	17.67 m.	9.99 m.	7.68 m.
Maximum curve	10°00′	6°00′	....
Total curvature	2,128°	187°	1,941°
Maximum grade	2.2%	2.2%	....
Tunnel grade	1.695%	1.565%	....
Summit elevation, subgrade	3,382 ft.	2,881 ft.	501 ft.
Total rise, westward	546 "	46 "	501 "
Total fall, westward	1,325 "	825 "	501 "
Snowsheds, total length	6.04 m.	....	6.04 m.
Bridges, total length	0.23 "	0.04 m.	0.19 "
Tunnels, total length	3.66 "	7.79 "	....

The purpose of the new tunnel is, therefore, sixfold: first, to effect permanent protection of the line from snow slides; second, to eliminate the annual maintenance charges incident to the upkeep and renewal of snowsheds; third, to reduce the operating costs throughout the heavy snow belt where rotary service is required during the winter months; fourth, to shorten the distance between Scenic and Berne by several miles; fifth, to eliminate the excessive curvature in the Martin Creek loop east of Scenic; and, sixth, to lower the summit elevation and to reduce the total rise and fall of the run between the two points mentioned.

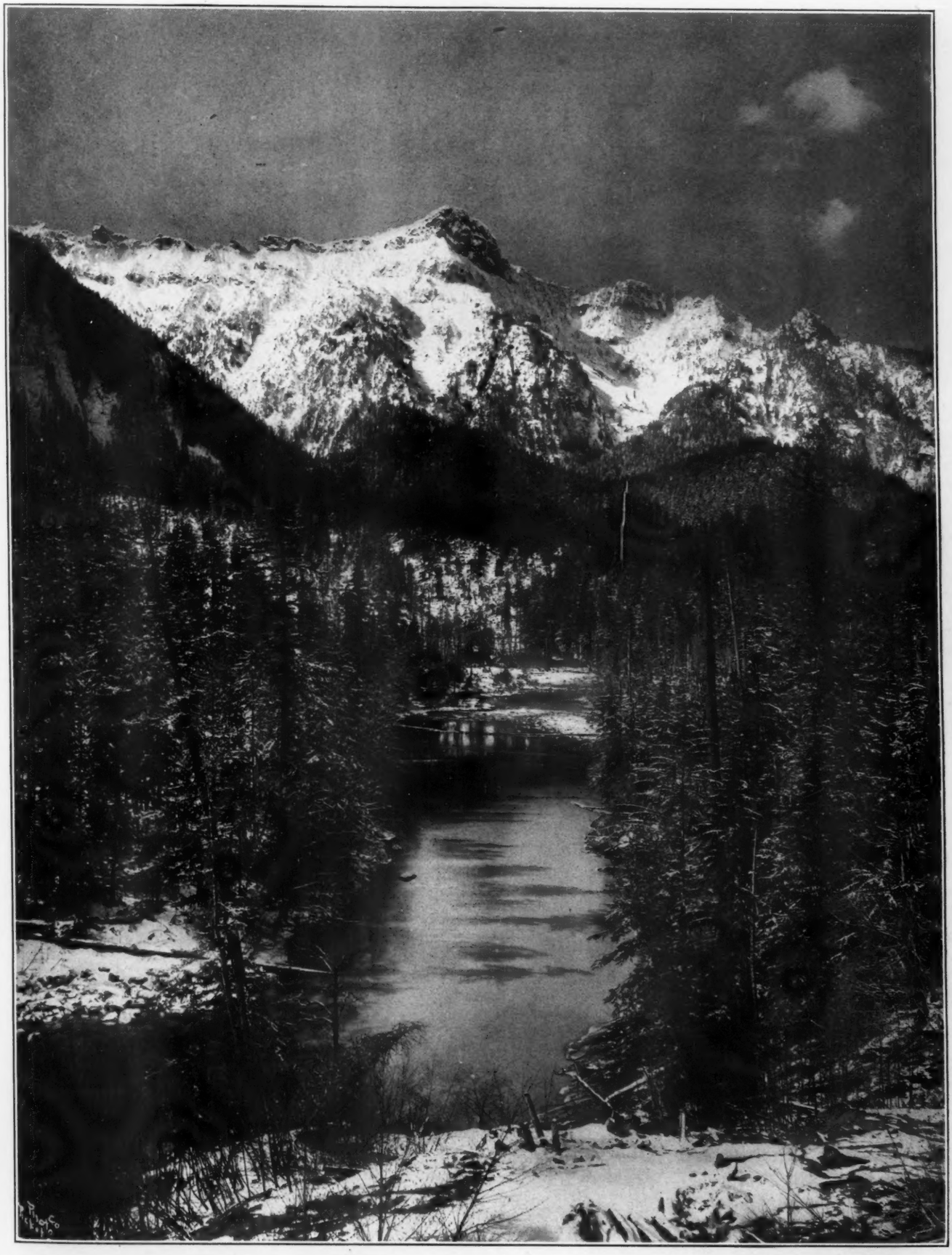
With the new tunnel, combined with the electrification of the Cascade Division, it will be possible to save an hour on passenger trains and two hours on freight trains moving east and west between Scenic and Berne. Inasmuch as there is a regular schedule of twenty-eight trains crossing the Cascades daily over the division—and most of these are freights, the total time saved every twenty-four hours will be of considerable moment.

On the new tunnel grade of 1.565 per cent. and on the remaining short sections of 2.2 per cent. grade approaching the tunnel from either direction, one big electric locomotive—that is, two units interconnected—should handle a train four times as heavy as any of the steam locomotives can now pull up the climb from Scenic to the top of Stevens Pass.

All told, it is estimated that the change of grade, the abandonment of snowsheds, the curtailment of snow service, the reduction in heavy track repairs, and the lessening of damage due to melting snow will lead to annual economies amounting to something like $1,400,000. Such being the case, it was apparent to the executives of the Great Northern that the sooner the work was begun and finished the sooner the savings would pay for the new tunnel and its associate features.

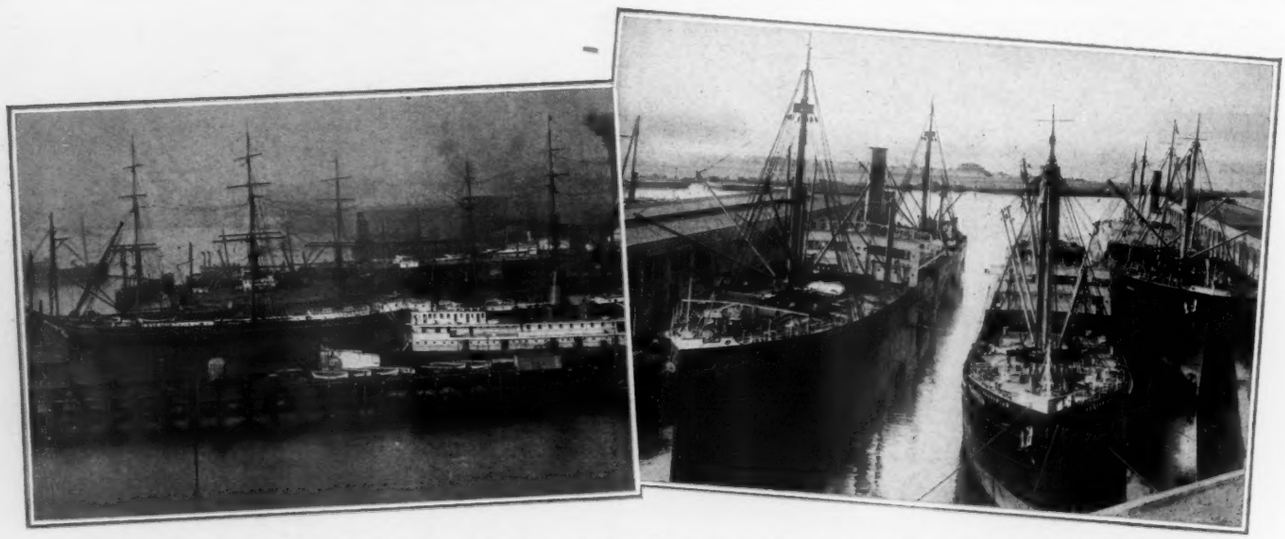
Therefore, having decided to spend approximately $10,000,000 in constructing the tunnel and its approaches, the first outstanding problem for the engineers of the Great Northern was to establish a new line over the Cascade Range as a guide in locating and building the new tunnel. The present operated road was used as a base line in a preliminary survey which revealed, in the fall of 1925, where it would be best to place the portals of the new tunnel. These points indicated where the contractor should begin his work and where, too, he should locate his two terminal camps. Later on an independent traverse was run out by way of the old tunnel; and from this was

Tumwater Canyon on the Wenatchee River. A hydro-electric plant on this stream furnishes electricity for work at the East Portal and at Mill Creek.



Pickett Photo. Company.

Approaching Stevens Pass from the west with towering Mount Persis in the distance cloaked in its wintertime mantle of snow.



In the harbor at Seattle can be seen all sorts of nautical craft from ports and countries in touch with the Seven Seas.

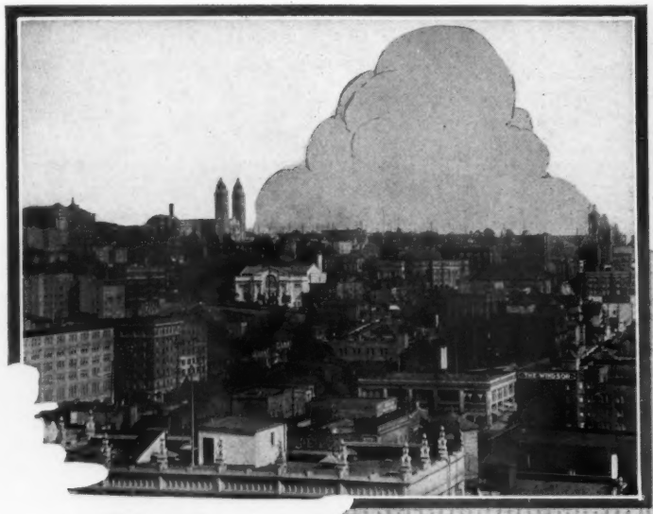
subsequently developed a system of precise triangulation, measured and checked by observations made across deep valleys from mountain top to mountain top, in some instances very hard to reach.

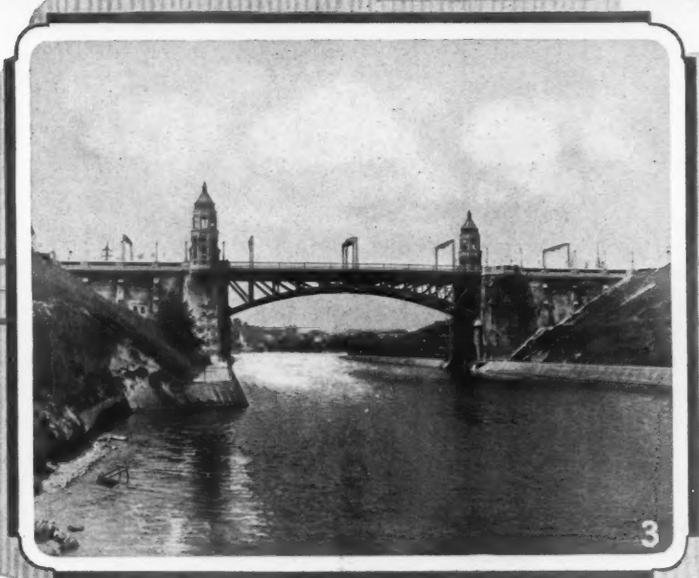
The first line was carried over the hills early in December of 1925, and its completion represented a month's work. The men engaged in this task deserve the highest praise. The successful climax of their labors called for patience, perseverance, and courage in the face of vexatious, exhausting, and even hazardous conditions. At times the surveyors were at elevations 6,000 feet above the sea, where cold and biting winds swept the observing stations; and yet for as much as a week running they remained, night and day, beside their instruments waiting for a brief period of visibility that would make an accurate sight possible.

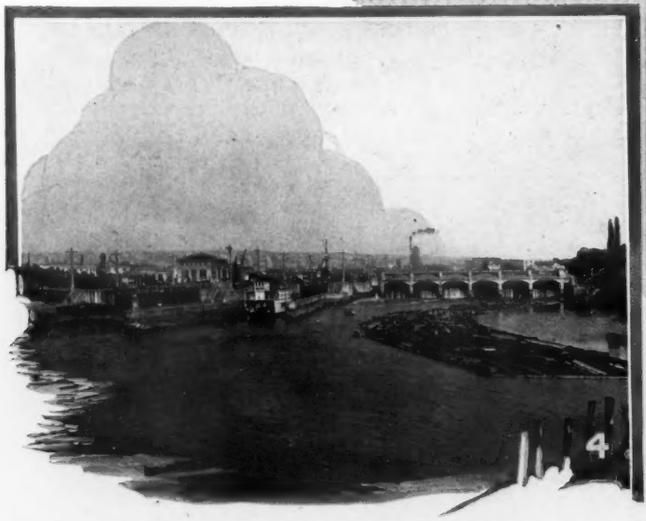
These preliminary trial lines were run with regular small mountain transits. Later, special precise transits were used to the check line and to locate permanent observation points on concrete monuments erected for the purpose on the mountain tops. The cement used had to be packed up on the backs of the surveying parties in 50-pound sacks, and water had to be carried there in the same manner in 5-gallon cans. The monuments were so accurately placed that they were not subsequently moved when a much more powerful instrument, a big theodolite with a telescope capable of magnifying 40 times, was employed in the ultimate triangulation that disclosed a variation of only 1.9 feet between the last line established by the standard railroad transits and the final line established by the theodolite. This is all the more surprising when it is recalled that wind currents caused so much refraction that errors amounting to 6 inches were common occasionally with the small instruments.

The special theodolite was a heavy affair—one piece weighing 69 pounds. This instrument had to be packed up to the mountain tops as had been the cement, water, food, etc.; and it was also necessary for the men to carry up the 5-foot lengths of 6-inch iron pipe that

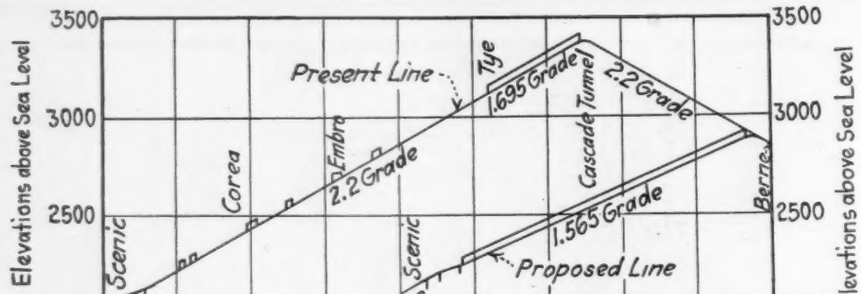
Snapshots along Seattle's very busy waterfront where many millions of dollars worth of commodities are handled in the course of a year.



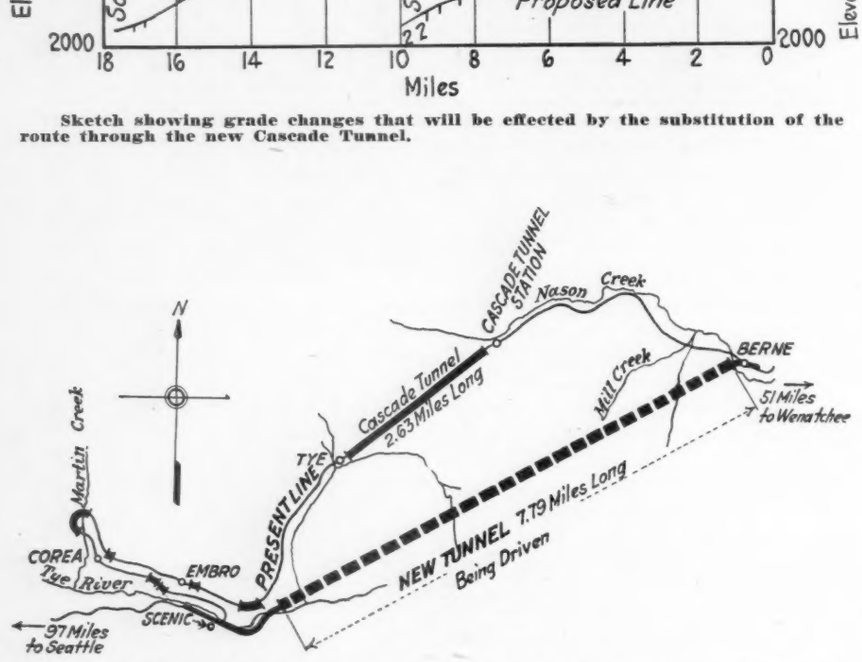




1—An aerial view of Seattle that reveals how the city is built on a series of terraces upon a rather steep hillside.
2—Seattle's business center is composed of broad thoroughfares flanked by imposing buildings.
3—Picturesque bridge over the canal adjacent to the University of Washington. Boat races are held upon this sheltered waterway.
4—The locks that link the fresh waters of Lake Washington with the briny tides of Puget Sound. These locks are said to be second in size only to those of the Panama Canal.
5—An attractive residential section of Seattle bordering upon beautiful Lake Washington.



Sketch showing grade changes that will be effected by the substitution of the route through the new Cascade Tunnel.



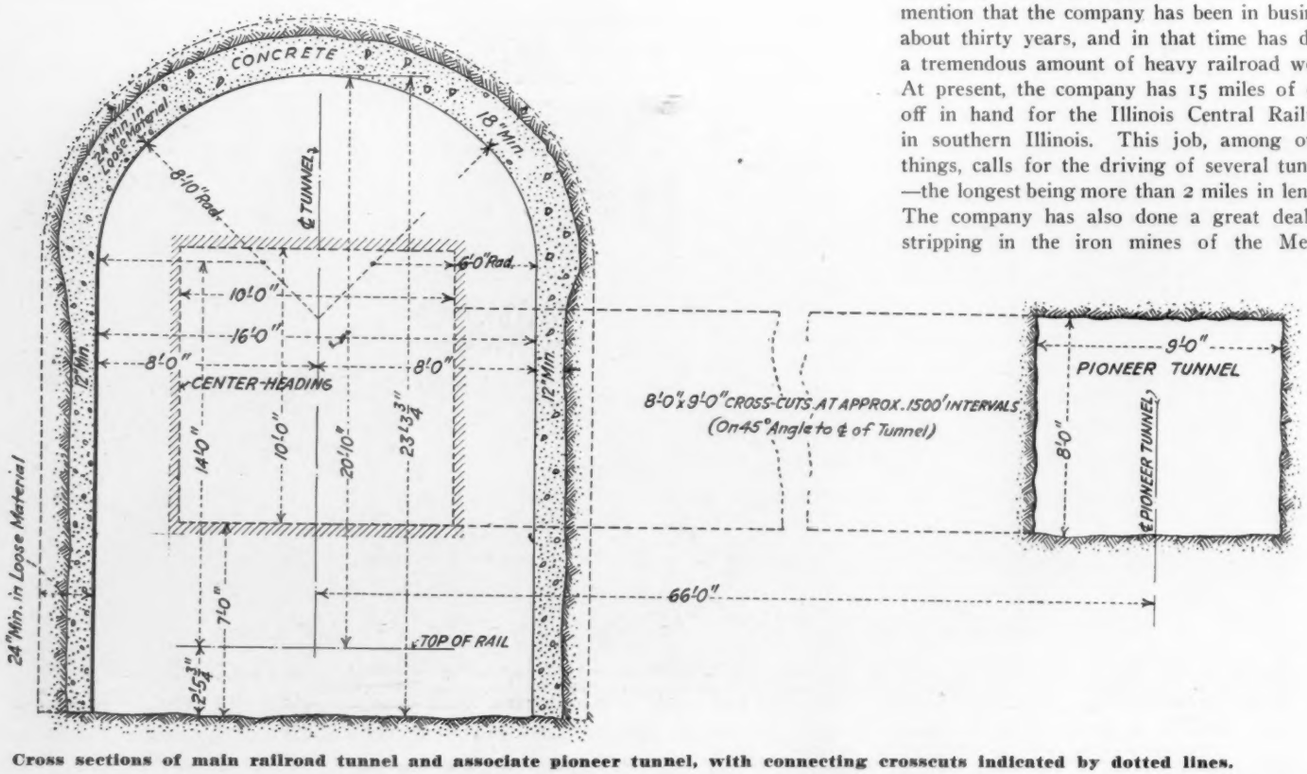
General plan of the existing line between Scenic and Berne and the route that will be followed when the new tunnel is completed.

surmounted the concrete monuments and formed the columns upon which the theodolite was mounted. It was possible with the big instrument to read directly to 2 seconds of arc. All sights with it were made either at dawn or dusk to avoid the distorting action of the sun upon the exposed iron-pipe support.

To facilitate unobstructed observation in determining the correct distances between the East Portal and the West Portal and between the East Portal and Mill Creek Shaft, swaths —ranging from 30 to 50 feet in width—were cut through the intervening timber along the base lines laid out as a part of the triangulation system. These details are mentioned to show how painstakenly the survey work was carried out in order that the exact length of the tunnel line through the mountain could be established and so that the tunnel line could be confidently depended upon to tie up with the portals when the work underground is finished. It will be understood, of course, that the surveyors carry the line underground as the tunnel driving progresses and mark the line right on the face of each heading to guide the drill runners.

On November 25, 1925, the Great Northern Railway awarded to A. Guthrie & Company, Inc., of St. Paul, Minn., the contract for the construction of the new Cascade Tunnel. The day following, the contractor picked out his camp site at the West Portal near Scenic. Work on the tunnel began at the West Portal on December 1, 1925.

Broad experience in railroad building and in the carrying out of other big construction work was the reason why the A. Guthrie & Company, Inc., was awarded the new Cascade Tunnel job. For the sake of those unfamiliar with this thoroughly qualified concern, let us mention that the company has been in business about thirty years, and in that time has done a tremendous amount of heavy railroad work. At present, the company has 15 miles of cut-off in hand for the Illinois Central Railway in southern Illinois. This job, among other things, calls for the driving of several tunnels —the longest being more than 2 miles in length. The company has also done a great deal of stripping in the iron mines of the Mesabi



Cross sections of main railroad tunnel and associate pioneer tunnel, with connecting crosscuts indicated by dotted lines.

Range; it has done important work on the Chicago Drainage Canal; it built the Cushman Dam of the Tacoma municipal hydro-electric plant; and has recently taken a large contract in connection with San Francisco's Hetch Hetchy water-supply system. All of which shows the company's special qualification for the task in hand on the Cascade Division of the Great Northern Railway.

Before describing how the tunnel is being driven it might be well to recapitulate some of the principal features of the project that have a bearing on the method of attack adopted —a method that has as its primary aim the speedy consummation of an undertaking that will involve the excavating of nearly 1,000,000 cubic yards of rock. These controlling features are:

No. 1. Length of tunnel, 7.79 miles.

No. 2. Grade, 1.565 per cent. descending from east to west, involving a drop of 634 feet.

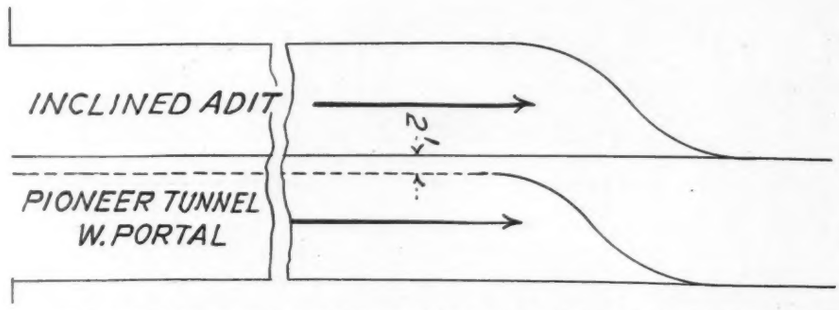
No. 3. Possibility of encountering water that might seriously hamper headings advancing down grade.

No. 4. Time available for the completion of the work only three years.

The finished single-track tunnel, when lined throughout with concrete, will have a clear width of 16 feet and a height of 20 feet 10 inches between the top of the rails and underside of the ceiling arch. The reasons for lining the tunnel are to prevent the spawling action of the air on apparently sound rock and to give support to rock that is manifestly unstable. The concreting of the arch of the railroad tunnel will be done pneumatically, while the walls to the spring line and the floor will be gravity placed. The ties will be set in concrete. A thoroughly modern sand-and-gravel washing plant, for both tunnel and main-line work, has been established at a pit about 3 miles east of Gold Bar and 32 miles west of Scenic.

Colonel Frederick Mears—assistant chief engineer of lines west on the Great Northern system, who is directly in charge of work on the undertaking, has thus explained the plan of attack developed to facilitate the driving of the main tunnel:

"The length of the tunnel and the time available indicated that more than two working faces were necessary. Controlling features No. 2, Grade, and No. 3, Water, were closely related, in that any plan of attack must of necessity consider the possibility of encountering water in such quantities that drifting operations down grade might be brought to a standstill. It was considered that all these difficulties could be overcome by sinking one or more shafts on the center line; and a study of the profile developed two possible shaft locations: one at Lanham Creek Valley, 630 feet above subgrade, and the other at Mill Creek Valley, 622 feet above subgrade. As Lanham Creek is only 2,500 feet from the East Portal, it was decided not to use this shaft location except in case it was necessary to abandon drifting operations from the East Portal on account of excessive water. It was decided, therefore, to sink a shaft at Mill Creek



This sketch indicates the relative positions of the inclined adit and the pioneer tunnel at the West Portal and how the two connect.

only, this shaft being located 2.41 miles west of the East Portal. The general plan adopted provided four faces of attack from three main camps; and is such that, in case of serious water difficulties, the entire tunnel could be driven up grade." This plan has been somewhat altered in detail but not in principle. One of these variations was at the West Portal. Again, Colonel Mears explains why this became necessary.

"The surface indications at the West Portal were such that it was thought that extremely soft ground would be encountered for a distance of 800 feet to 1,000 feet. A 30° incline adit, 251 feet long, was therefore driven to the pioneer level in the Tye River Canyon. This adit intersected the pioneer line and pioneer grade at a point 2,270 feet from the West Portal. Subsequent developments justified this move, as the material encountered in the main pioneer was of such a character that only 100 feet of advance was possible during the month of April, 1926. This slow progress was counteracted by the good progress made on the pioneer drift from the incline adit."

In short, when the main pioneer tunnel coming in from grade reached the 8x9-foot inclined adit, work thence on the pioneer tunnel had penetrated eastward a distance of more than 3,400 feet and two crosscuts had been driven to the center heading in the main tunnel. Ample indication of the wisdom of the course followed. The inclined adit was driven off to one side of the pioneer tunnel—as indicated by an accompanying sketch, or 6 feet from center to center, and then joined with the line of the 8x9-foot pioneer tunnel by a reverse curve. The reverse curve was a safety provision designed to take care of any cars that might break loose or drop down the incline—the curve being counted upon to divert them and to prevent them from running wild onward through the pioneer tunnel. The surveyors threw their line down the adit and carried it thence into the main pioneer tunnel—the 2-foot overlap of the adit and the pioneer tunnel giving a clear way for this operation.

(To be continued)

Trade papers have lately announced the development in Great Britain of a new printing process—known as the "Pantone" process, which is said to be a combination of letterpress and lithographic printing.

Pickett Photo. Company.

Surface activities at the inclined adit near the Tye River, West Portal. This adit was driven in advance of starting the pioneer tunnel with which it later connected.

Novel Use of Water Column to Maintain Pressure in Air Line

By S. G. ROBERTS

BUTTE, Mont., boasts the "richest hill on earth." Whether or not this description is exact, there is no denying that the Anaconda Copper Mining Company has withdrawn from the bowels of that hill many millions of dollars worth of ore. In the mining of that ore, the company has used and is using a great deal of compressed air for the operating of rock drills, the working of large mine hoists, and for various other essential purposes.

Much of the air employed on the property is provided by eight big motor-driven air compressors—each having a capacity of 7,500 cubic feet of air per minute. These compressors maintain a line pressure of 90 pounds to the square inch; and the number of the compressors in service depends, of course, upon the operating load which varies in accordance with working conditions and the changing demand from hour to hour.

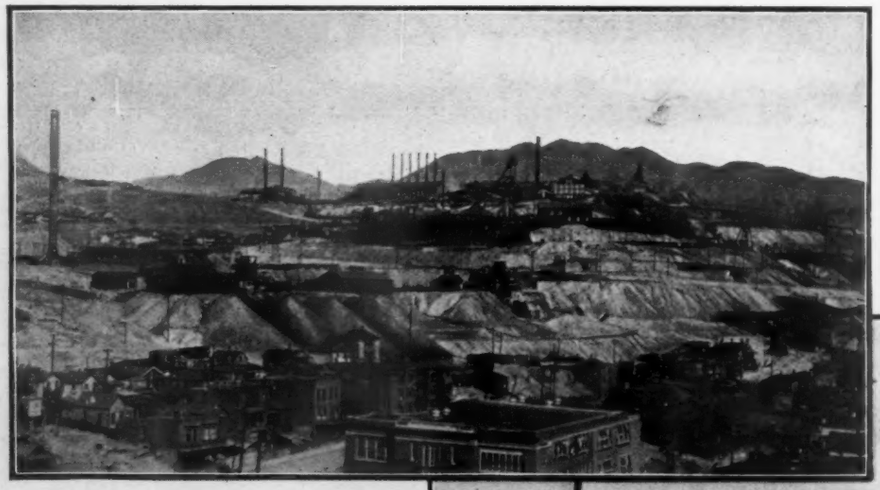
Each compressor is driven by a large synchronous motor making 75 revolutions a minute. Before any one of these motors takes over the load of the associate compressor it is necessary to have the compressor in motion at the required synchronizing speed. The compressors are, therefore, run for a brief while as prime movers by reversing their operating cycle by feeding compressed air to them. Five of the machines can be started in this manner with air at a pressure of 25 pounds, but the three other units, when cold, require air at 70 pounds pressure to turn them over and to bring them up to the necessary speed. It takes skill and nice judgment on the part of the engineer to bring the compressor in this way exactly to synchronizing speed before throwing in the motor and shutting off the impulse air feed.

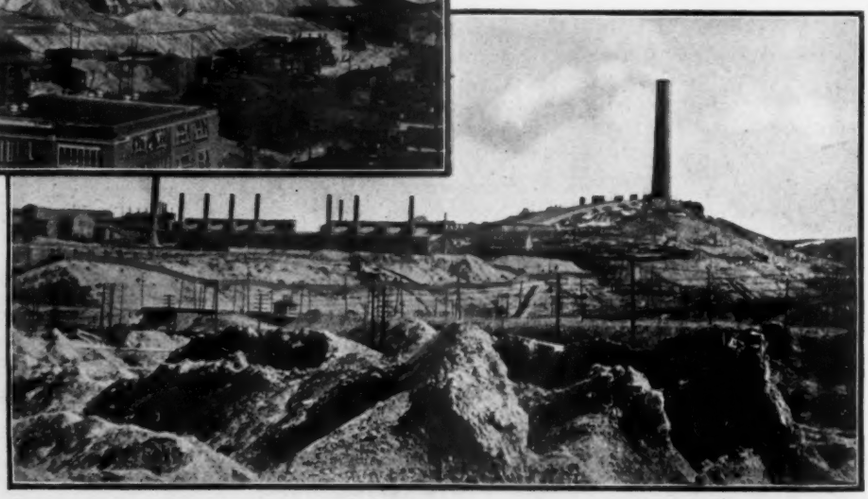
Because the air load does vary sharply at times, and the demand for more air comes suddenly and before one or more idle units can be brought into action, the engineers of the Anaconda Copper Mining Company have called into being an auxiliary installation which automatically prevents a serious drop in the line pressure. This installation is capable of sustaining the line pressure for a period of from 15 to 20 minutes—long enough, in other words, to give the machines in the compressor house ample time to get into full swing and to insure sufficient air to keep the pressure in the line at the prescribed 90 pounds. The importance of this provision can be realized when it is recalled that hundreds of rock drills, many pumps, and some of the hoists would be halted or seriously affected should the air supply fail them.

As one of our illustrations shows, the air discharged from the big motor-driven compressors is led to a numerous battery of large receivers, located outside the compressor house; and these receivers are connected with a second group of sixteen receivers placed more than 200 feet below on the neighboring hillside. It is from this second group of receivers that the air is drawn that goes to the different underground workings. Each of these secondary receivers is 10 feet in diameter and 70 feet long.

These receivers are connected, by means of a 42-inch pipe, with a tank on top of the hill adjacent to the compressor house—the compressor house being 1,300 feet away from the receivers. This water tank is 10 feet deep and has a diameter of 100 feet; and the hydrostatic head between the tank and the bottoms of the sixteen receivers is 209 feet—that is, sufficient to insure a pressure of 90 pounds when the water column is acting upon the volume of air in the receivers. The 42-inch main is connected with the receivers by a gooseneck arrangement which extends to a point 26 feet below the bottom level of the receivers. The purpose of the gooseneck is to act as a safety device to allow for change of pressure from 90 to 103 pounds before withdrawing water from the large tank. Now let us see how this installation functions.

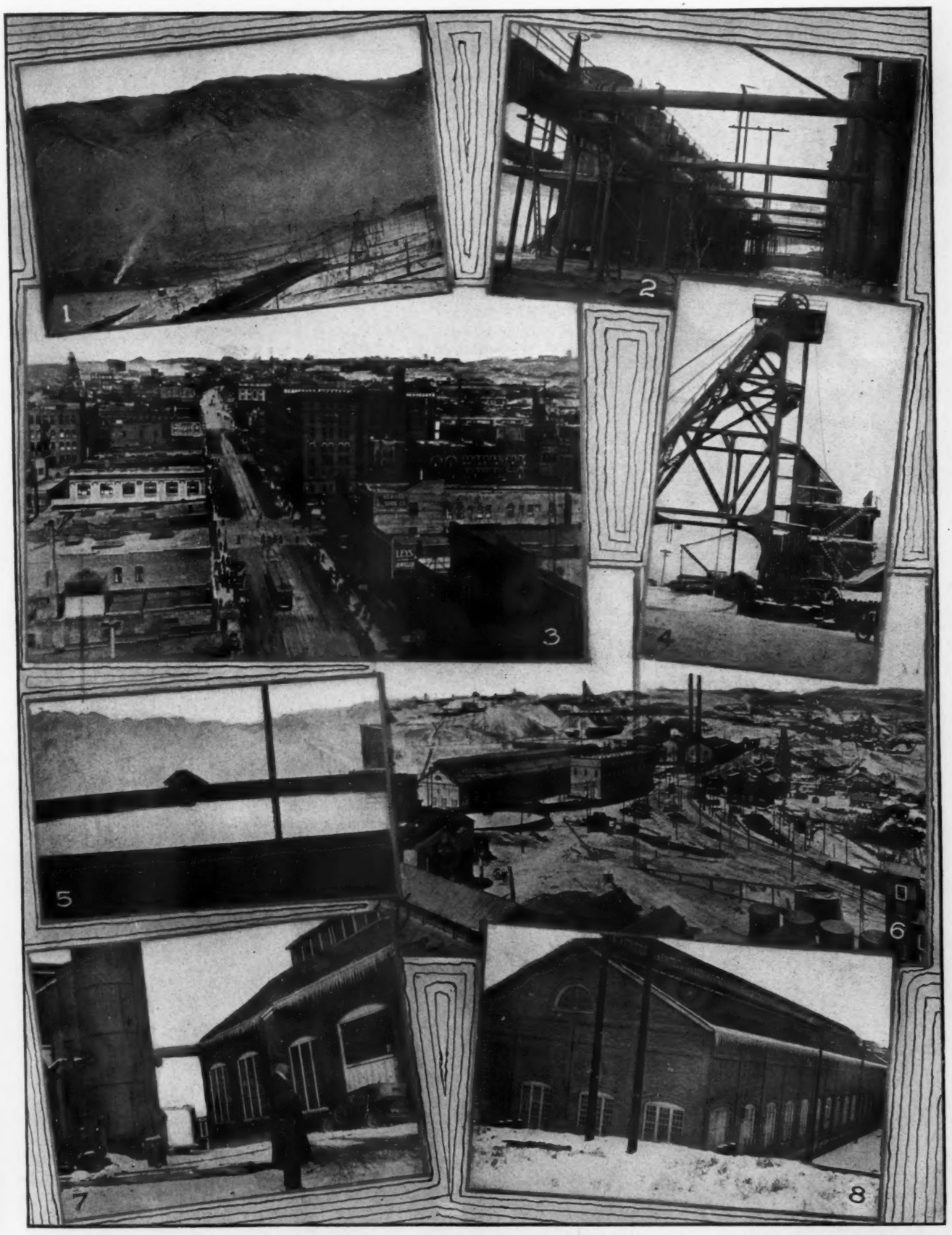
Normally, with the air supply at the designed maximum pressure in the line, the sixteen secondary receivers are filled with air and entirely drained of water—the water level being at the top of the gooseneck immediately beneath the bottoms of the receivers, and the pipe line and the tank on the hilltop also being filled. The moment a sudden overload on the receivers exceeds the capacity of the compressors operating at the time, then the weight of the column of water in the tank and the connecting 42-inch main overbalances the air and the water crowds into the receivers. This move-



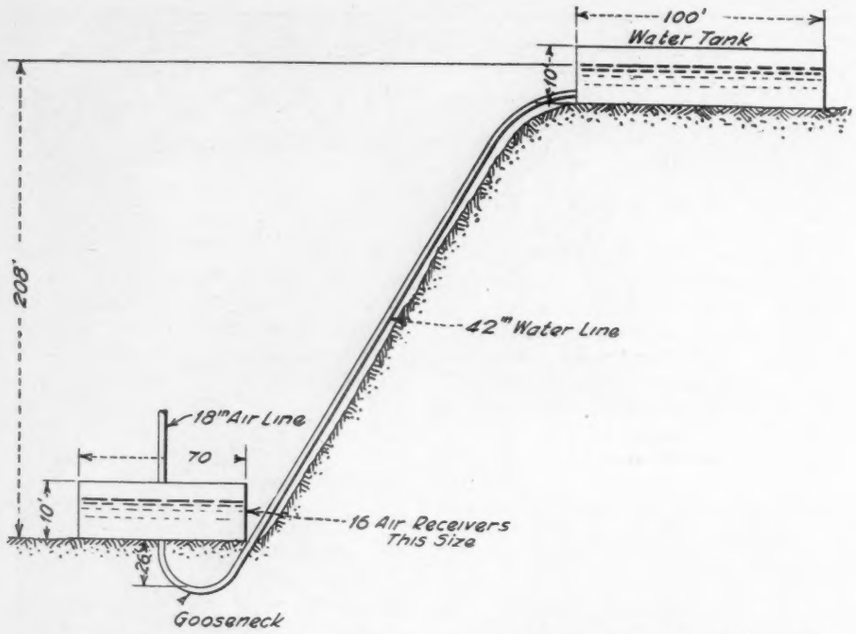


Top—"The richest hill on earth" from which the Anaconda Copper Mining Company obtains its ore at Butte, Mont.

Right—The smelter of the Anaconda Copper Mining Company.



1—Group of sixteen air receivers in the foreground. 2—Battery of air receivers outside the main compressor plant. 3—Part of Butte's business section. 4—One of the big air-operated mine hoists. 5—The tank on the hilltop that feeds water to the group of sixteen air receivers located 200 feet below. 6—General view of main compressor plant and water tank for the receivers below on the hillside. 7—Air receivers and hoisting-engine house for one of the air-operated mine hoists. 8—Main compressor house of the Anaconda Copper Mining Company.



Hydraulic installation that automatically maintains the working pressure in the main air line.

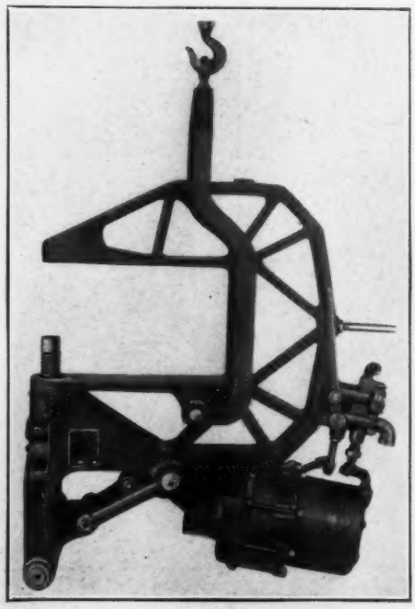
ment continues until the air in the receivers is sufficiently compressed by the incoming water to bring the pressure up to the prescribed 90 pounds. In other words, the invading water supplements the output of the compressors running at that moment and really serves to make up the pressure deficiency by displacing and compressing the air remaining in the receivers. The water continues to flow into the receivers until the compressors are working fast enough to meet the demand and to build up the air pressure to a point where the water will be forced down and out of the receivers and back and up through the main to the big tank on top of the hill.

The tank, when the surface of the water is 8½ feet above the bottom, contains 66,759 cubic feet of water; and that level remains constant so long as the counterbalancing air pressure in the secondary receivers continues at 90 pounds. When the air pressure drops below that maximum, the water starts to flow downward from the tank and up and into the receivers. While on a somewhat pretentious scale, the installation is simple in its get-up; and its effectiveness has been established so often that there is not the slightest question about its dependability and value in safeguarding this great mining property from short but costly shutdowns.

After a careful study of the cross-river traffic, a special commission has pronounced the bridges spanning the River Thames, in the London district, inadequate because of the steadily increasing movement over them. As a result, the commission has recommended the widening and the strengthening of existing bridges, the building of several new bridges, the driving of a tunnel, and the reconstruction of certain of the roads tributary to the bridge.

BIG YOKE RIVETER OF IMPROVED DESIGN

RIVETED-steel structures of many sorts have well-nigh innumerable fields of application or service. In the fabrication of some of these steel bodies, the final assembling must be done at or near the place of use or erection. Because much of this steelwork is fashioned of heavy material, calling for the employment of large rivets to do the necessary binding or assembling, it is essential that those rivets should be put in place not by hammer blows but by recourse to pressure applied progressively and maintained until the rivet has been completely upset, made tight, and permitted to cool to a measurable degree.



This portable yoke riveter is capable of exerting a pressure of 50 tons on the rivet die when operated with air at a pressure of 100 pounds.

Work of this nature can be done with forms of portable riveters that exert the required energy through the motive medium of either water or compressed air under suitable pressure. Much engineering skill has been devoted to the developing of power riveters of this class; and the accompanying picture illustrates one of the latest of these machines that is manufactured by the Hanna Engineering Works, of Chicago, Ill. This riveter, known as the Hanna portable compression yoke riveter, weighs only 1,500 pounds; has a reach of 24 inches and a gap of 15 inches; and is capable of exerting a pressure of 50 tons on the rivet die with air at 100 pounds pressure.

GOVERNMENT URGES USE OF SHORT-LENGTH LUMBER

BY ordering short-length lumber from the mills instead of sawing it from full lengths it would be possible to increase the lumber output of the United States by one-fifth without the felling of an additional tree or the investment of an additional dollar in mill equipment, it is declared in a report by a governmental committee headed by Herbert Hoover, Secretary of Commerce. Under the present practice, no short-length lumber is produced at the mills. This results in the wastage of short-length logs—an extravagance which dates back to the time when the timber supply of this country was believed to be inexhaustible.

The report, made public by the Department of Commerce, is the work of the National Committee on Wood Utilization appointed by President Coolidge to bring about a fuller utilization of the country's timber resources. The committee comprises over 100 members, and represents manufacturers, distributors, and consumers of lumber and wood products. Photographs, charts, and figures are presented to show where short-length lumber could be used at a saving of from 15 to 35 per cent. on present prices quoted at the mills. The substitution of short lengths for long ones is particularly applicable in the construction of small homes and farm buildings.

Summarizing its findings, the committee states that "the saving of tens of millions of dollars annually in construction and the conservation of billions of feet of soft-wood lumber are two great economies that can be effected by the use of short-length lumber."

A preliminary announcement has been made by the National Machine Tool Builders' Association of an exposition to be held in Cleveland, Ohio, from September 19 to 24, inclusive. This is the first exposition of its kind to be staged by that association, and is intended primarily to coördinate scattered efforts and to bring about annually an effective presentation of the products of the industry for the benefit only of those interested in machine tools and accessories.

Havana, Cuba, boasts the narrowest street in the world—the Via Sol, which is only 47 inches wide.

Homes Built of Rammed Earth

This Ancient Method of Construction Has Been Recently Revived in the United States

By C. H. VIVIAN

AN interesting experiment in housebuilding by Prof. Ferdinand N. Menefee, of the Department of Engineering Mechanics at the University of Michigan, involves the use of compressed air in fashioning walls of rammed earth. Using for wall material only the soil underfoot, Professor Menefee has, during the past year, constructed in Ann Arbor an attractive 6-room, 2-story residence which does not in any way differ in appearance from adjoining homes.

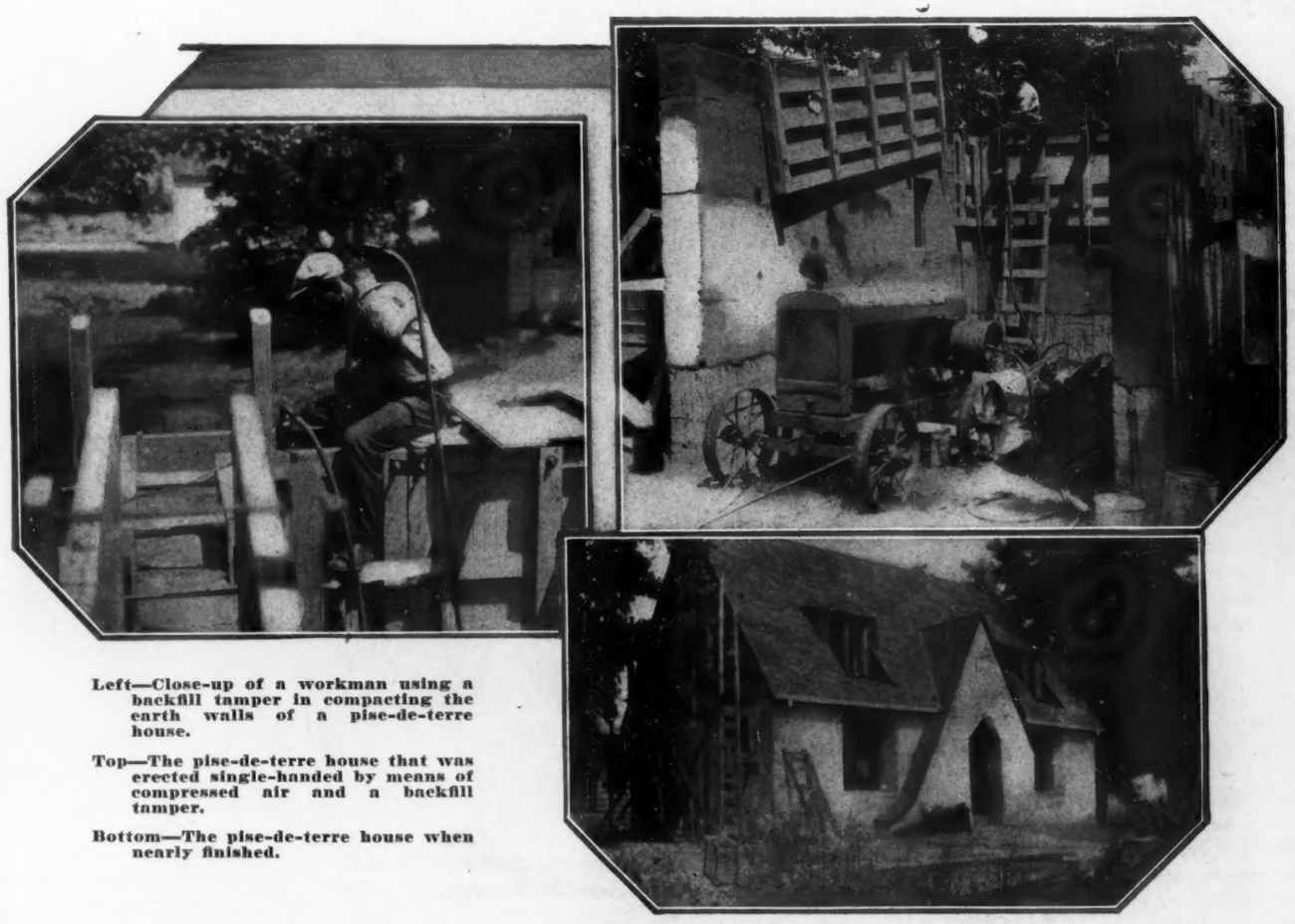
While novel to this country, more especially as regards urban dwellings, this method of housebuilding is rooted deep in history and has persisted through the ages in various parts of the world. Abroad, where it is extensively used, it is termed *pisé de terre*, meaning rammed earth. Pliny refers to it in his Natural History. Monsieur Gorffan, who published a treatise on rammed-earth houses in 1772, is authority for the statement that they were introduced into England by the Romans. In the Lyonnaise Province of France, and in certain provinces of Spain, the method has been practiced for centuries. Today it is employed in India, New South Wales, Rhodesia, and elsewhere the world over. The Soviet government of Russia has printed pamphlets on the subject to assist peasants with their housing problems.

The first house erected in this country at St. Augustine, Fla., is reputed to have been of rammed earth. Thomas Jefferson was an ardent advocate of this mode of construction, but he found little opportunity to promote the scheme with apparently inexhaustible forests at hand and Europe sending to our shores hordes of laborers to open up quarries and to manufacture bricks.

In foreign lands, *pisé de terre* has persisted primarily because of its low cost and facility of assembling. Its widest field of application has been in rural districts, where the expense of hauling brick, stone, or lumber is a considerable item in the total construction bill. The mass of materials required can be appreciated by recalling figures compiled by the *Country Life Magazine* of England in 1918. This source of information reveals that the average home built in the British Isles at that time called for 200 tons of materials.

A rather pronounced revival of rammed-earth construction has been apparent in England since the beginning of the World War The factors that helped to bring it about were the costliness of ordinary building materials and the scarcity of labor. Coincident with that revival extensive experiments were undertaken to shed additional light on such matters as the proper earth to use, the best manner of compressing it into masonry structures, the strength of such walls, etc. Exhaustive investigational work in this direction was carried on by the Ministry of Agriculture and Fisheries of the British government. In the meantime, various individuals were interesting themselves in the same line of research. One of them, Clough Williams-Ellis, published a book which includes several chapters on the subject.

In the United States, the social and industrial systems have not lent themselves to a serious consideration of rammed-earth buildings. Indeed, the average citizen whose thoughts turned



Left—Close-up of a workman using a backfill tamper in compacting the earth walls of a pise-de-terre house.

Top—The pise-de-terre house that was erected single-handed by means of compressed air and a backfill tamper.

Bottom—The pise-de-terre house when nearly finished.

to a home of his own probably would have felt certain that something was being foisted upon him if an architect had suggested a *pisé-de-terre* house. Nevertheless, sane and experienced men in the building crafts have approved it from the standpoint of feasibility and practicability, though it is patent that considerable time will elapse before the general public's interest passes the stage of mild curiosity.

The completed home, illustrating the architectural beauty achieved with pise de terre.

It was with the full realization of these things that Professor Menefee set about to construct the home which is now finished and occupied. Associated with him was Roswell E. Franklin, instructor in his department. Their method of procedure was precisely that employed by Hannibal's legions in Spain, except that they took advantage of modern machinery and called upon compressed air to do the work which for centuries had been carried on by hand. In adopting up-to-date equipment, they found that they could secure better results at a considerable saving in time.

The Ann Arbor house is 23x36 feet in ground dimensions. Adjacent to it is a 10x16-foot garage. The rammed-earth walls of the house were made 18 inches thick and were carried to a height of 9 feet above the foundation. The material excavated from the basement was used in the walls until it became too sandy. Then recourse was had to earth from a nearby street that was being dug up preparatory to paving.

In general, any soil that will sustain vegetation can be successfully used. The essential qualities demanded being firm coherence of the particles without excessive shrinkage in drying. Clay would satisfy the first requirement but not the second, while sand would answer admirably from the one standpoint but would be totally inadequate from the other. Obviously then, a mixture of sand and clay is most adaptable; and the average soil in which things grow meets the imposed conditions.

Prior to starting building operations, Professor Menefee made up samples from soils of varying compositions and containing varying quantities of moisture. These samples were formed by ramming the earth with air-driven tools into iron cylinders 6 inches in diameter. After drying for periods ranging from a number of days to several months, the amount of shrinkage was recorded, the loss of moisture by weight was noted, and the cylinders were then tested for compressive strength. Some of the samples resisted a crushing force of 35 tons to the square foot. This compares with 30 to 40 tons for common brick and 200 to 400 tons for pressed brick.

Regardless of the dictates of laboratory tests, Professor Menefee declares that for all practical purposes full reliance can be placed in the following simple building method which seems, from the literature on the subject, to have been used from time immemorial. At the selected site, dig a few inches below the surface, take up a handful of soil and grip it tightly. If it clods readily, it contains enough clay to give it proper cohesive qualities. Then let the clod fall from the height of your waist. If it breaks easily when it strikes the ground there is in it enough sand to prevent the clay from cracking when the moisture is expelled. The limit of permissible moisture is roughly 15 per cent. If more is present the earth cannot be satisfactorily compressed.

In the Ann Arbor project, no material was added to the earth as it came from the ground. However, the earth was frequently tested to make sure that it contained at least 25 per cent. of clay. To prepare it for use, it was gravity-sifted through a screen of 1-inch mesh. This served to remove undesirable pieces of rock, as well as to facilitate subsequent handling and ramming. All organic matter, such as roots and stems, was carefully excluded, as it tends in drying to shrink to a greater extent than the earth and thus to weaken the coherence of the mass. By reason of this fact, top or vegetable soils are commonly held unsuitable for use.

The molds utilized in building the *pisé-de-terre* house were similar to the familiar forms employed in rearing concrete walls. They were made of wood, the proper gage being maintained by means of iron cross rods which permitted the easy adjustment of the side walls or shuttering. Some difficulty resulted from the absorption of moisture by the wooden frames. Professor Menefee therefore decided that metal side plates might prove more satisfactory. Each mold was 10 feet long and 3 feet high, enabling the erection of wall segments of approximately those dimensions without readjustment.

An air-driven backfill tamper is an effective aid in building a house by the pise-de-terre method.

The basement walls were built of 8-inch concrete blocks, the hollow spaces being filled in with concrete. An 18-inch wide cap was placed on top of the subsurface walls. The upper surface of this cap was treated with a thin coating of hot tar and tar paper to make the joint damp-proof. After that the ramming of earth into the wall molds was started. Power—that is, pressure, was furnished by a portable compressor and was applied through an I-R backfill tamper. In Europe, where hand ramming is practiced, wooden rammers of about 7 pounds weight are commonly used.

A layer of approximately 5 inches of loose earth was shoveled into the mold at a time. Under repeated blows of

2—Courtesy, Dept. of Agriculture. 4.—© Underwood & Underwood.

1—An English house of rammed-earth construction.

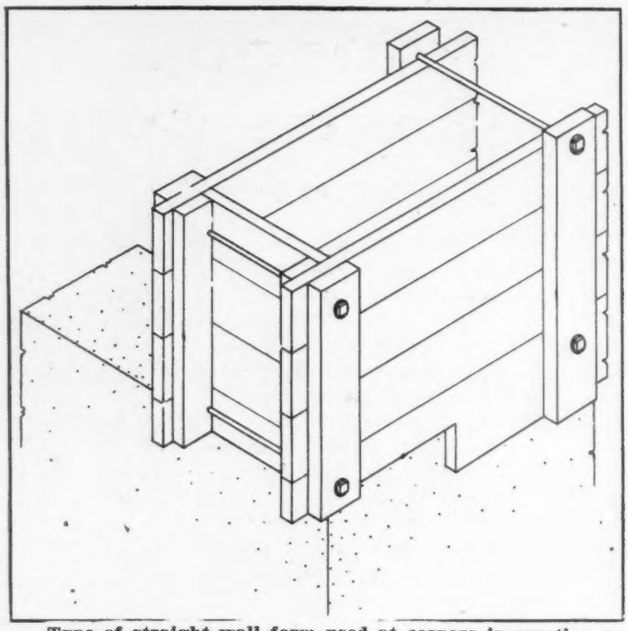
2—The main portion of this house, near Washington, D. C., was built of pise de terre in 1773. The portico and the rooms at the rear were added in recent years.

3—In constructing this house near Washington, D. C., rammed-earth walls were reared on a concrete-block foundation.

4—The walls of the lower story of this house, built by the original Spanish settlers of St. Augustine, Fla., are of pise de terre.

the air-driven tamper it was compressed to a thickness of 2½ inches. This procedure was repeated until the mold was filled. At either end the earth was sheared off at an angle so that a stronger union might be formed with the next overlapping section.

To allow for window and door openings, suitable stops were inserted in the mold at proper intervals. Wooden plugs were set in the jambs for securing the frames. Fire flues for the two chimneys were constructed within the walls—the enclosing earth being gaged with cement. A composition shingle roof was employed—the freshly built walls proving compact and strong enough to allow the roofing to proceed without delay.



Type of straight-wall form used at corners in erecting an earth-rammed building.

Various exterior finishes are suitable for *pisé-de-terre* walls. The British governmental bureau already referred to recommended three as especially applicable. These were mixes of sand with ground lime, chalk lime, and cement, respectively, the proportion of materials in each instance being 1 to 1. The favored finish in the past has been hot tar. Upon cooling, this forms a base for any desired paint. It is asserted by some English writers on the subject that an experienced builder can ram walls whose interior surfaces are so smooth that they can be papered as they stand.

Professor Menefee reports that both the exterior and the interior wall finishes varied greatly in the Ann Arbor house. He attributes this to faulty mixing of materials. In places where too much sand was allowed to creep in, spots developed. To prevent fretting, these spots were patched with mixes richer in clay. The outside surface was not very smooth. While this was unintentional, it proved to add to the architectural beauty of the house. The interior walls were painted with the ordinary ground coat of plaster left rough in imitation of Tiffany finish. They were then tinted with a paint formed by adding coloring material to white cement.

The garage walls, being lower and having less weight to support, were made only 6 inches thick.

In discussing the economies of *pisé-de-terre* construction in the United States, Professor Menefee says: "There is some doubt in my mind as to this kind of building for cities unless a large subdivision could be built all at once, so that the cost of equipment could be spread over a number of houses. My firm belief is that it will prove more popular in the country districts, where the cost of the hauling of materials is necessarily added to their first cost."

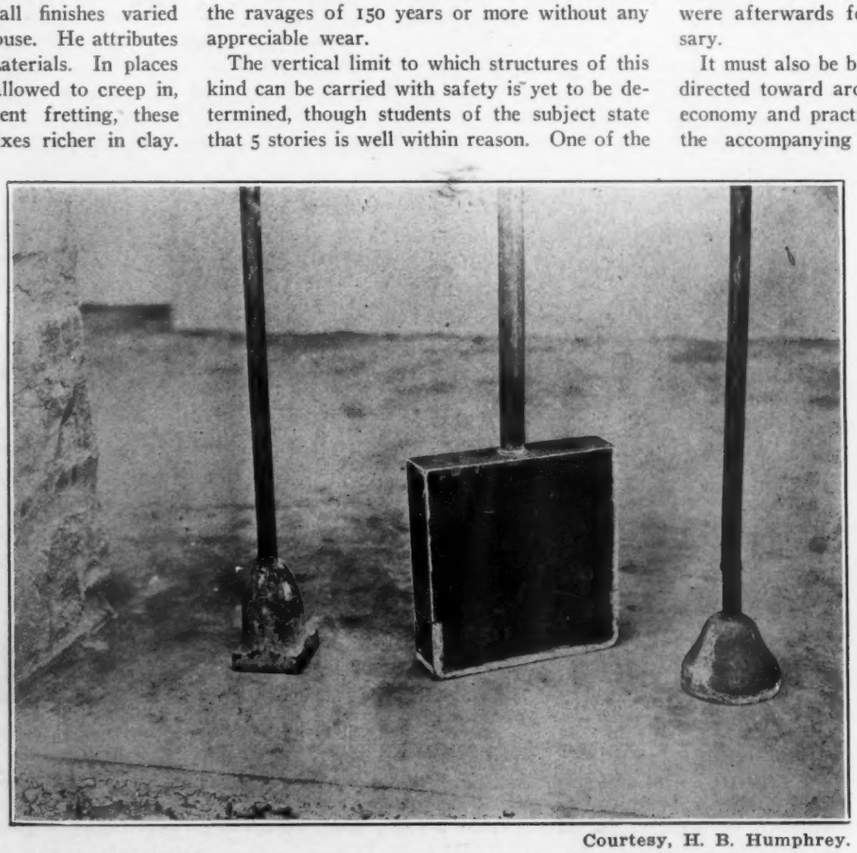
The durability of rammed-earth walls is best attested by examples of this type of building in various parts of Europe today. Hundreds of peasant families in France and Spain are nowadays occupying homes which have withstood the ravages of 150 years or more without any appreciable wear.

The vertical limit to which structures of this kind can be carried with safety is yet to be determined, though students of the subject state that 5 stories is well within reason. One of the medieval writers refers to a Spanish *pisé-de-terre* church 80 feet long, 40 feet wide, and 50 feet high, which was in use for 80 years. During that period the only attention given the walls was a coating of rough cast every 10 or 15 years. A fire occurred which left only the walls standing. When these were razed, great difficulty was encountered in reducing them to pieces small enough to be readily handled. The walls were 18 inches in thickness throughout their height, though the prevalent custom is to taper the walls of relatively high buildings.

With properly organized gangs of labor, walls of rammed earth can be reared with surprising speed. Three layers of 3 feet each can be laid in one day without endangering the strength of the wall, thus making it possible to build a vertical stretch of 9 feet in that period. This very thing has been done in England in the course of the experimental work previously referred to. Construction cannot, however, be carried on during rainy weather unless the scene of operations is fully protected.

The cost of rammed-earth construction, under favorable conditions, is held to be the lowest obtainable. In the case of the Ann Arbor house, the total cost was slightly more than it would have been for a wooden structure of the same dimensions. This Professor Menefee explains was due to various expenditures that were afterwards found to have been unnecessary.

It must also be borne in mind that effort was directed toward architectural beauty as well as economy and practicability. As can be seen in the accompanying photographs, this striving toward attractiveness was achieved. But, at the same time, it complicated the structural details and brought the time and the cost factors far above those that would enter into the building of an unembellished earth-rammed house having the same room capacity.



Courtesy, H. B. Humphrey.

Kinds of rammers sometimes used in rearing a pise-de-terre structure.

"More than 80,000 square miles of land in the Province of Alberta," says Dr. John Allan, professor of geology in the University of Alberta, "have petroleum possibilities. The presence of vast deposits of natural gas and coal, which occur almost invariably with petroleum, make it seem likely that the province will be a great future source of oil supply."

Another Record of Savings Made Possible By An Oil-Engine Compressor

By G. P. PROCTOR

TOWARDS the middle of the eighteenth century, the art of potterymaking began to flourish in the County of Stafford, England. Hitherto pots had been just dull pieces of clay for utilitarian purposes only; but in the skilled hands of Wedgewood, the famous Stoke potter, the uninteresting clay became richly decorated pieces of china of beautiful form.

With the industry thus established, experiment and research soon convinced the manufacturers that the best pots were produced by mixing flint stones, ground to a required fineness, with the clay. A medium had then to be found which would be sufficiently tough and sharp to grind the flint stones as desired; and it was this necessity, it is believed, that led to the discovery of chert in the limestone hills of the neighboring County of Derby.

Chert is a siliceous limestone that is sometimes called hornstone. Its chemical analysis shows from 75 to 95 per cent. silica—the balance being chiefly limestone with traces of iron, magnesium, etc. The deposit lies in surroundings of great beauty and antiquity. There the River Wye flows gently through the valley, and on its banks nestles the quaint old town of Bakewell, whose charter dates back to 1000 A. D. A few miles farther down, overlooking the river, is Haddon Hall, a stately castle made famous by the romantic elopement in the sixteenth century of its heiress, Dorothy Vernon, with John Manners, son of the Earl of Rutland. Incidentally, Haddon Hall still belongs to the Rutland family, and is the county seat of the present Duke of Rutland.

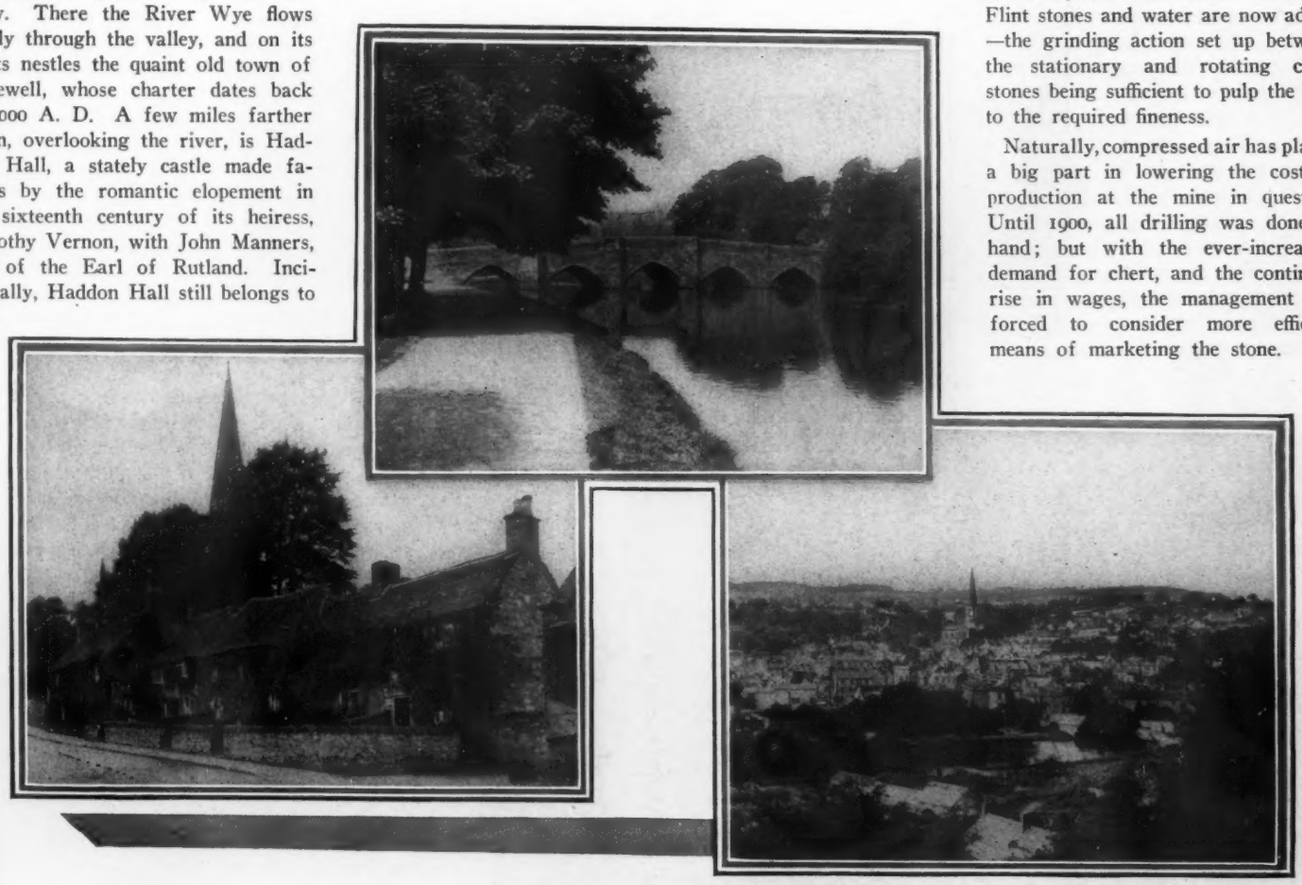
The chert seam runs straight into the hillside, at Holme Bank, and is slightly inclined to the horizontal—that is, the seam extends from east to west and dips toward the east. The seam has an average thickness of 4 feet. This fact, together with the high silica content of the chert, ranks it as the finest deposit in the world. The other known deposits of this rock formation are few in number. Several are to be found in the British Isles, notably in Yorkshire and in Wales, and others are located in the continental countries of France and Belgium.

The chert is mined in three main gates or horizontal shafts at different levels, but with the exits close together. At this writing the levels penetrate the hillside to a depth of 500 yards. From these radiate fanwise the shafts leading to the chert face, which is about a quarter of a mile in length. The exact date of the opening of the mine is not known, but the records available prove definitely that work was in progress there when the American Colonists were fighting for their independence.

The method of mining employed is to undercut the limestone upon which the seam rests to a depth of 3 feet and with a penetration of 8 yards—the seam being pillared up while the miners are at work. The pillars are then blasted away and the chert falls down in lots of from 50 to 100 tons. The blocks are next cut up and loaded on a trolley that carries them by gravity to the outside where they are squared up and cut into the sizes demanded by the pottery manufacturer.

The manufacturers demand two kinds of stone—runners and pavors. Each runner weighs from 10 to 50 hundredweight, while a pavor weighs anywhere from ¼ to 1 hundredweight. The method of grinding the flint stones is interesting. The bottom of a large cylindrical pan is lined with the pavors, and on top of these are placed the runners. An axle, provided with a number of arms, fits into the top of the pan and is rotated by machinery. When the axle is set in motion, the arms carry the heavy runners round with them. Flint stones and water are now added—the grinding action set up between the stationary and rotating chert stones being sufficient to pulp the flint to the required fineness.

Naturally, compressed air has played a big part in lowering the cost of production at the mine in question. Until 1900, all drilling was done by hand; but with the ever-increasing demand for chert, and the continued rise in wages, the management was forced to consider more efficient means of marketing the stone.



Top—Bakewell Bridge.
Left—Old cottages in Bakewell.
Right—Bakewell from a hilltop.

Accordingly a 12x12¼x12-inch Ingersoll-Sergeant, Class "F," steam-driven compressor was installed, together with several large piston or reciprocating drills of the same make. Later, the piston drills were replaced by BCR-430 "Jackhamers"—this type of hand drill being quicker to manipulate and easier to move around than the heavier type of hand drill. Today, "Jackhamers" are used not only for undercutting the limestone but also for splitting the great chert blocks into marketable sizes. The latter process, of course, is aided by means of plugs and feathers.

The enginehouse is the building at the right.

In 1925, the management realized that the steam compressor could not meet the demand for air, which had increased enormously in the post-war years. And as the price of coal had more than trebled since their boiler plant was first installed, the company decided to scrap the existing plant and to replace it with the most up-to-date and economical compressor on the market.

This led to the installment of an Ingersoll-Rand Type POV-2, oil-engine compressor—the 2-stage compressor being direct connected to a single-cylinder, 4-cycle, Diesel oil engine. One of the accompanying pictures illustrates a number of interesting points about this unit. For example, the mounting of the air cylinder vertically on the oil-engine frame is such as to require a minimum of floor space, a factor which is of real importance to quarry owners because the space available at existing hillside plants is often limited. Then, too, the direct connection of engine and compressor not only prevents belt and other transmission losses but also affords a saving of at least 20 per cent. in the power required to drive the compressor.

Haddon Hall with the River Wye flowing beneath the bridge in the middle distance.

The oil engine is of the horizontal-cylinder, single-acting, solid-injection, cold-starting, 4-cycle type. Injection is accomplished by means of two opposed spray nozzles to which oil is delivered under pressure by an injection pump. Compressed air is not required for this fuel injection. Ignition is by heat of compression only, and the engine starts cold. Compressed air is furnished for starting. A small petrol-driven engine, direct connected to a vertical compressor, pumps air into a starting tank at a pressure of 200 pounds per square inch. A water-cooled check valve on the oil engine charges the tank each night direct from the engine compression. It is therefore not necessary to use the petrol-engine-driven unit for every stop and start, but only when the tank fails to keep its required pressure. This may occur over the week-end.

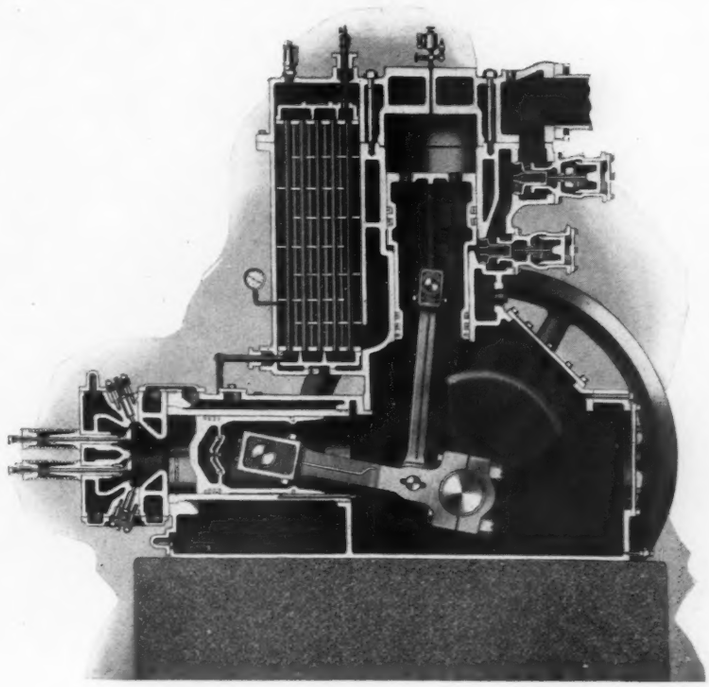
The water-cooling tank is at the left in the shadow of the building.

The regulation of the air-compressor cylinder, for both low- and high-pressure cylinder, is effected automatically with by-pass control valves. The oil-engine compressor has a piston displacement of 322 cubic feet per minute. A comparison of the running costs of the oil-engine compressor and of the old steam-driven compressor shows a very considerable saving in favor of the oil-engine unit. It should be remembered, too, that the POV-2 plant delivers at least 130 cubic feet more air per minute than the steam-driven compressor.

The old engine did not run as many hours a day as does the oil-engine compressor; it re-

quired a man stoking; and the coal bill was from £25 to £35 a month. To this must be added the cost of the lighting set for the mine—a 4-H.P. paraffin engine coupled to a 3-H.-P. electric dynamo. The operating costs of this machine average £4 per month. Now, the electric dynamo for lighting purposes is driven from one of the crowned flywheels of the oil-engine compressor; and the total fuel bill of this unit, which supplies both lighting and compressed air in the mine and which operates 8½ hours a day, is only about £6 to £7 per month.

The little chert mine, nestling on the slopes of the Derbyshire Dales, has in the course of 150 years seen and kept in touch with the progress of civilization. The old eighteenth century miner, proud of his hand drill, would stand aghast if he could but come back to earth and view a modern quarry plant.



Vertical cross section of the POV-2 oil engine installed in the plant of Joseph Smith & Sons at Bakewell, England.

CATERING TO AMERICA'S SWEET TOOTH

IT required $394,000,000 worth of confectionery to satisfy America's sweet tooth in 1925, according to figures made public by the United States Bureau of Census. This total production of our candy factories represents an increase of 4 per cent. over the 1923 output. Chocolates proved to be the favorite choice of the people—295,704,000 pounds of this variety, valued at $102,790,000, having been manufactured in that twelvemonth.

The census, which is taken biennially in the field of manufactures, shows that in 1925 there were 1,928 establishments engaged in the business. Pennsylvania led the states, with 215 factories; New York came next, with 196; and California was third, with 191. The nation's candymaking industry utilized 98,956 H.P. in its activities.

To what extent the X-ray is now serving industry is strikingly brought out by the following list of applications. This list should be of interest in view of the fact that it is not so many years ago since the X-ray was restricted in its use to science and medicine. According to *Machinery*, it is employed to detect bits of metal in insulating fiber; to establish the centrality of the metal in electric cables and of the cores in golf balls; to find out whether steel balls are sound; to tell whether the stems of thermometers are made of soda glass or of lead glass; to examine the fit of a shoe; to estimate the amount of ash in coal; to show the turns of wire in a coil covered with insulation; to determine the internal diameter of metal tubing; to examine the internal construction of explosive devices, etc., etc.

PNEUMATIC DRILL DRIVES MIXING PADDLES

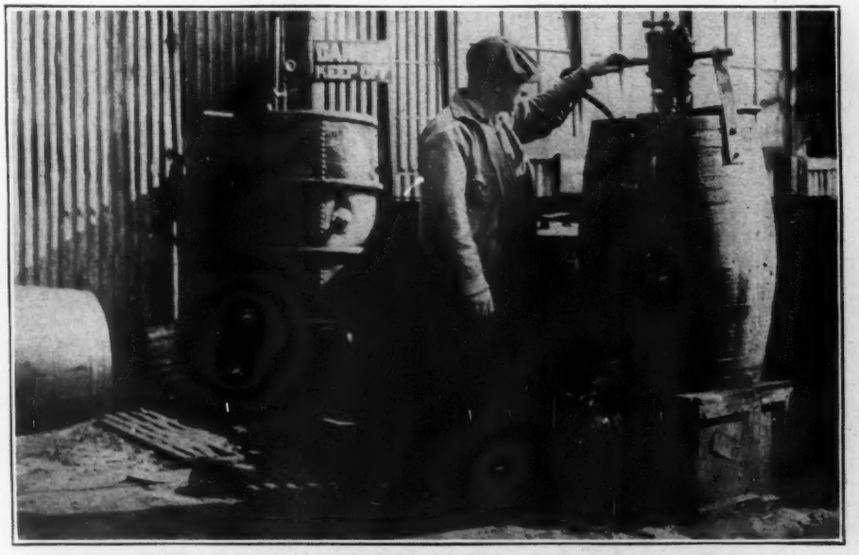
THERE is a growing tendency in the United States to encourage workmen, by the offer of commensurate premiums, to suggest ways and means by which they can do their work faster and better than is possible for them to do it under existing conditions. This is a healthy state of affairs, as the man on the job—familiar as he is with what is required—should be well qualified to improve either the method or the machine employed by him day in and day out.

Experience has shown that compressed air, because of its adaptability, readily lends itself to many novel applications; and in most plants, where it is available, compressed air or air-driven equipment has done much to lighten the workman's labors if not actually to help him do his work better and faster.

For example, to make it easier to bring about a thorough admixture of a cutting compound and paint, someone in the plant of the Caterpillar Tractor Company, of San Leandro, Calif., conceived the idea of using an air-driven drill to do the stirring—drawing air from the line running throughout the shops.

As our illustration shows, the drill is suitably secured to the top of the mixing barrel—the drill operating paddles that make short work of a job that previously had been a slow and heavy one. In the drum at the left is the cutting compound, which is heated before it is placed in the mixing barrel. While being heated, the compound is agitated with compressed air introduced into the drum for that purpose.

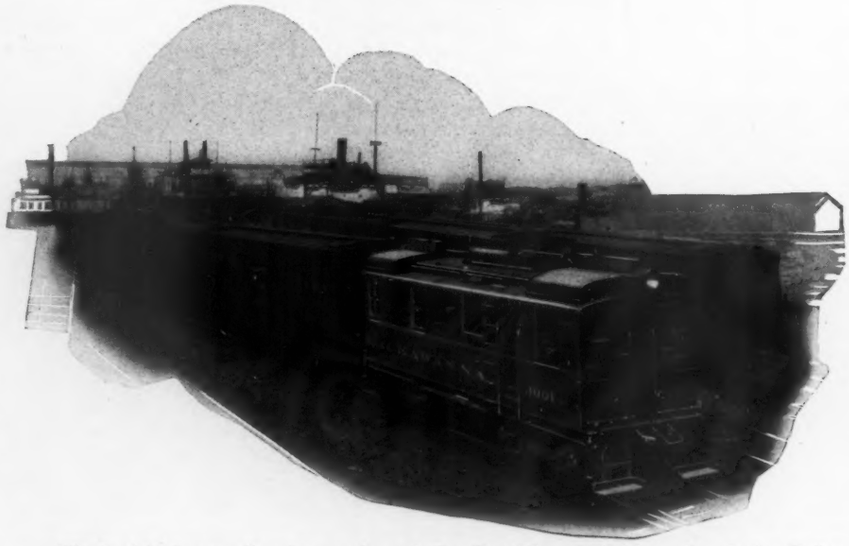
As a result of experiments conducted by Prof. Royal W. Sorenson, assisted by Dr. Robert A. Milliken, there has been developed in the famous 1,000,000-volt laboratory at the California Institute of Technology a vacuum switch for high-tension currents. The switch functions on the principle that electricity will not travel through a vacuum. The terrific arc produced when a current of 1,000 amperes is cut off in the open air is eliminated in the case of the new device. It is claimed that the vacuum switch will be of great commercial value.



Pneumatic drill adapted to operate a paint-mixing paddle.

Oil-Electric Locomotive Easier on Track and Roadbed

BECAUSE it considerably reduces the wear and tear upon steel rails, the oil-electric locomotive — the newest thing in railway motive power—promises to save the railroads of the country a great deal of money. Power experts and railway economists, who have been studying the performance of the oil-electric locomotive on the various railroads on which it has been operating from six months to a year, declare that the stresses imposed by the new type of locomotive on track and roadbed are less severe than those put upon them by the steam locomotive.



Oil-electric locomotive in service at the Brooklyn freight yards of the Delaware, Lackawanna & Western Railroad.

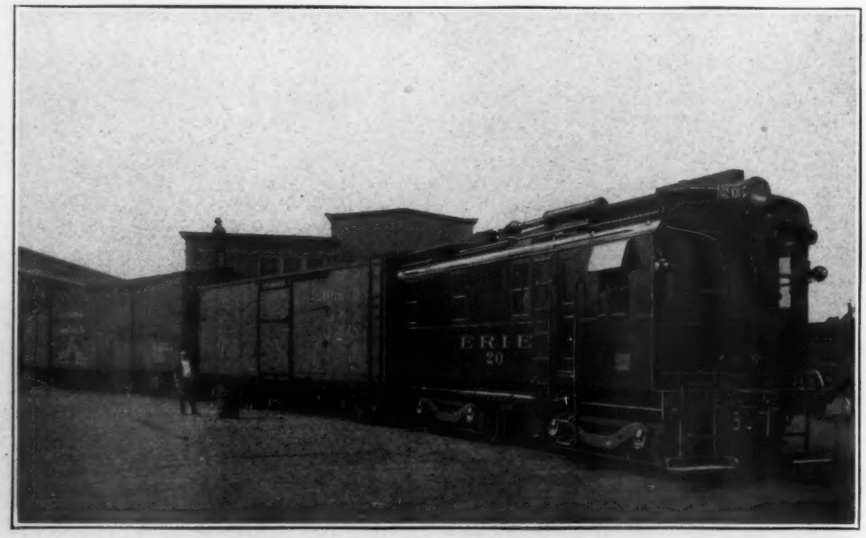
In an authoritative book on *Diesel Engines*, just published, David Louis Jones says of the oil-electric locomotive: "This locomotive provides uniform, continuous torque at the wheels, which results in less wear on the tracks and provides higher tractive effort at starting and slow speeds on much lighter axle loads." The expense of rail and roadbed maintenance on 250,000 miles of right of way in the United States runs into hundreds of millions of dollars annually, and railroad systems are trying in every way to reduce this cost.

In the case of the oil-electric locomotive—the joint product of the Ingersoll-Rand, American Locomotive, and General Electric companies, the operation of starting is not accompanied by jerking, by tugging or by slipping of wheels. This is due to the nature of its power transmission system, which enables the full effect of the driving oil engine to be utilized at all speeds.

Aside from the economy effected in the use of fuel—an outstanding characteristic of the oil-electric locomotive, it is capable of making a rapid start from a standstill; and it is on its way, without waste of power, and doing its work before the steam locomotive has begun to accelerate.

The fact that the oil-electric locomotive can work faster and in closer quarters than the steam locomotive is pointed out by David Louis Jones in his book in connection with recent tests, on the Central Railroad of New Jersey, in which the oil-electric locomotive moved more cars on and off floats in 61 hours than did a steam locomotive in 75 hours. At the same time, the oil-electric shut down its engine while not at work and waited for more cars to haul, while the steam locomotive was obliged to keep its fires banked for 69 additional hours—the fuel burned in that interval representing a heavy loss.

The cost of fuel and of lubricating oil for the oil-electric locomotive for this work was $11.90 as against $73.35 for the steam locomotive, Mr. Jones recites. He also deals with the ease with which the oil-electric, with its two control handles, is operated, and stresses the fact that it can be counted upon to do the hardest kind of railroad work.



This 60-ton oil-electric locomotive is employed in New York City in the freight yards of the Erie Railroad.

Chemists at the Pittsburgh Experiment Station of the United States Bureau of Mines have developed a new respirator that is said to be superior to other devices worn as a protection against injurious dusts encountered in mining and other industries.

AN ACCIDENT POINTS WAY TO PROFITS

THAT accidents often lead to important discoveries and inventions cannot be gainsaid. An interesting example of this recently occurred at the White's Landing lead and zinc mill on Catalina Island, Calif., says the *Engineering & Mining Journal.*

In painting a tramway, newly erected above the ore bins, the man on the job spilled the contents of his bucket over the ore and was severely criticized for his awkwardness. Later, in checking up the percentage of recovery from that particular ore it was found that it had increased from an average of 36 per cent. to 48 per cent. This meant a gain of about $110 on the day's run of the mill.

Upon investigation it was discovered that the kerosene and the linseed oil in the paint tended to precipitate the iron pyrites, which had proved troublesome up to that time. It is estimated that the accidental spilling of the paint will increase the net annual profits of the White's Landing mill by approximately $50,000.

It has been estimated that the oil-shale deposits of Tasmania amount to more than 43,000,000 tons and contain on an average 40 gallons of crude oil to the ton.

Waters of Ausable Chasm Now Produce Electric Current

By A. S. TAYLOR

AUSABLE Chasm has long been one of the scenic wonders of New York State. Through the Chasm flows the Ausable River, which is the outlet by which the waters of Lake Placid find their way northeastward to Lake Champlain. The flanking walls of the Chasm, which rise precipitously to heights ranging from 100 to 200 feet, are composed of Potsdam sandstone—the oldest member of the Paleozoic series within the limits of the Empire State. In its geological sequence, this rock lies at the base of formations many thousands of feet in thickness; and the sedimentary substance of which the sandstone is composed was laid down in the far-off ages of the Cambrian period. Just how remote that was need not concern us—it is enough to know that the scientist is satisfied in his mind that the time was thousands and thousands of years in the past.

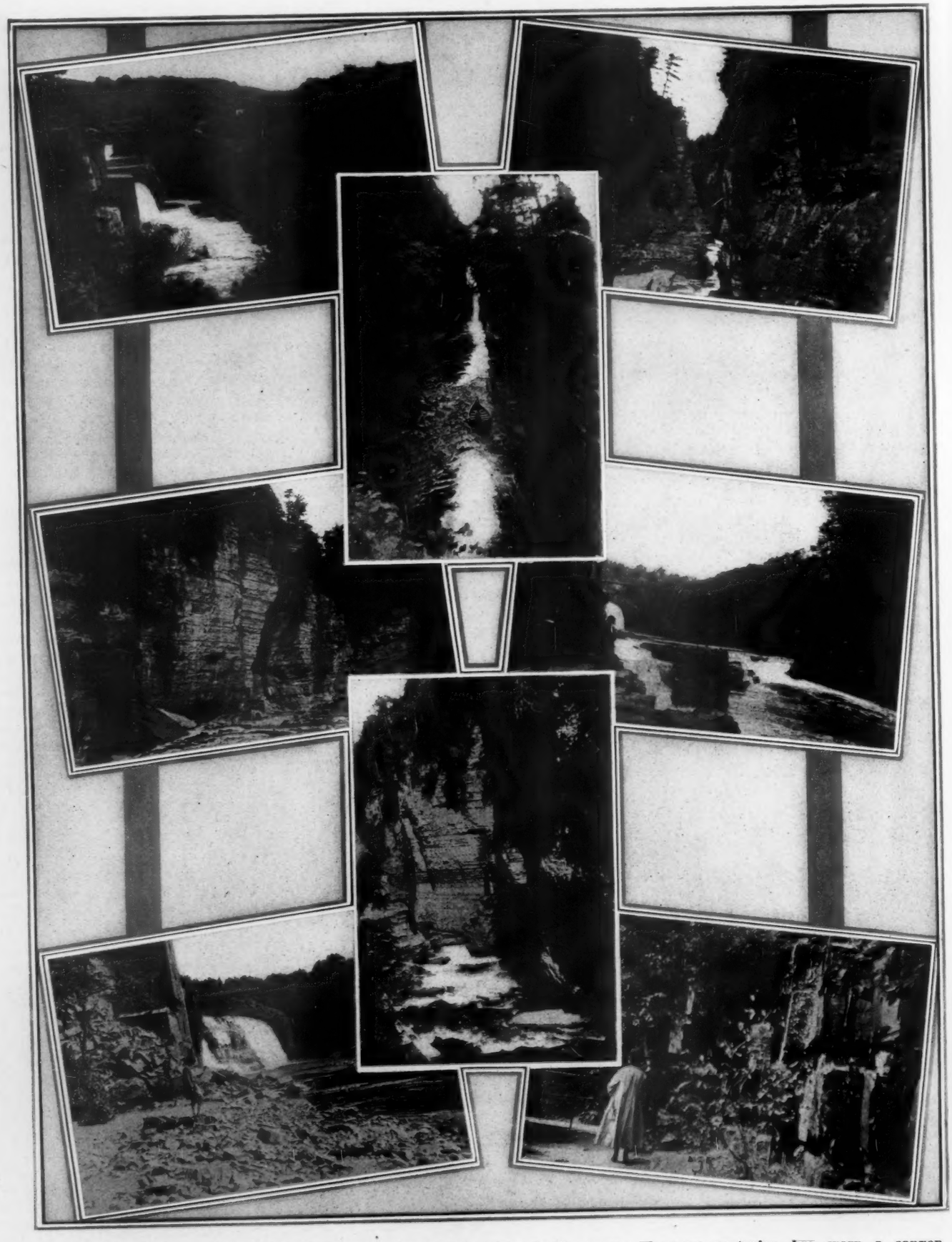
In those aeons gone what we now know as Clinton County, and in fact a vast adjacent area lying between the Adirondacks on the west and the Green Mountains of Vermont on the east, once lay beneath an invading sea. When that was the case, a sandy silt was deposited hundreds of feet deep; and under the action of enormous pressure this deposit became compact and was transformed into stone which, long afterwards, was shoved upward when the earth's crust heaved and the sea was displaced by the mountains that now flank the region—leaving Lake Champlain, for example, as a reminder of that remote geological period.

When the ice cap that covered New York State retreated, the glacial lakes of the territory found outlets for their overflowing waters by the most convenient valleys, and in this way the sand-bearing Ausable River was born as a link between Lake Placid in the Adirondacks and Lake Champlain lying to the eastward. No doubt, the volume of water flowing from Lake Placid was once much greater than it is now even during the freshet stages of springtime, and the erosive action then was probably correspondingly more intense. Be this as it may, it is reasonably certain that Ausable Chasm, as we know it today, has been cut out of the massive sandstone by the wearing action of the Ausable River and by the abrasive sand which that stream has been carrying down with it for thousands of years.

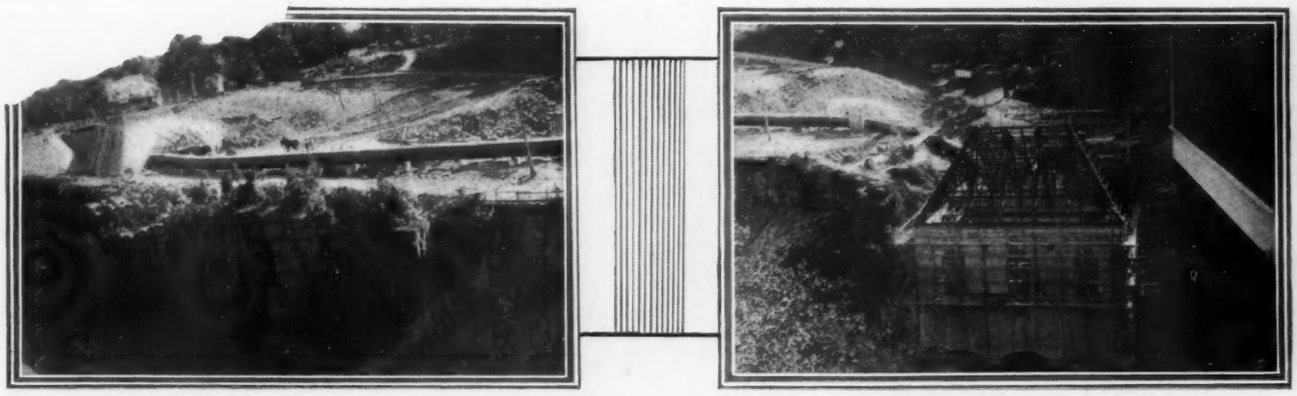
In the course of time the river has carved its way and produced the Rainbow Falls, with their drop of 70 feet; has scoured out the Horseshoe Falls; and has otherwise gouged a deep channel for itself through the sandstone which was in all likelihood a solid mass before the river sought an outlet into Lake Champlain. The generally horizontal markings on both walls of the Chasm plainly indicate the successive levels of the stream and the gradual way in which the rushing, tumbling, precipitous waters cut their way continually downward and deeper. As a consequence, the confining cliffs have assumed fantastic and impressive forms—some of them so nearly perfect in their details as to suggest the deliberate handicraft of a titan race of the far-off past. But checking any further flight of fancy, the fact remains that Ausable Chasm is an extremely picturesque and marvelous example of what natural forces can accomplish in the course of ages. Because of this, the Chasm has been visited by increasing numbers of admiring tourists for years; and during those decades nothing has been done to utilize the power latent in the waters flowing through the 2-mile length of the Chasm. Recently, however, a hydro-electric plant has been completed that will make use of the water's energy in a way that will not impair the scenic charm of either the Chasm or of the two falls that constitute striking features of this natural wonder.

The powerhouse and the associate features were undertaken by the J. & J. Rogers Com-

Top, left—The power plant is in the middle distance between Rainbow Falls and the nearer Horseshoe Falls. Right—Gate-house and gates controlling the flow of water into the steel penstocks.
Bottom, left—The dam just above Rainbow Falls with the reinforced-concrete forebay near by. Right—The portable compressor that supplied air for various purposes during the construction of the powerhouse and its associate features.



Picturesque phases of Ausable Chasm where the Ausable River, in the course of many centuries, has worn a canyon through the Potsdam sandstone.



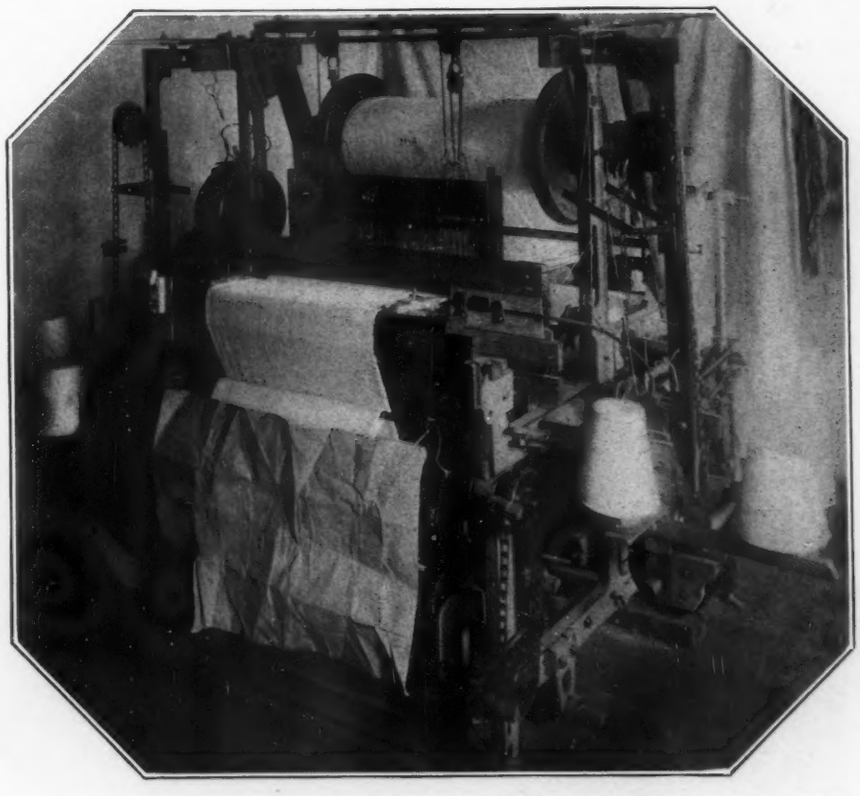
Left—One of the penstocks by which water from the pool above the dam will be delivered to the waterwheels in the powerhouse down in the Chasm.
Right—The Ausable Chasm hydro-electric plant nearing completion.

pany of Ausable Forks. The primary purpose of what is known as the Rainbow-Estes Station is to furnish electric current to the sulphite and paper mills operated by the company at Ausable Forks; but sufficient power will be developed to make it possible for the plant to distribute energy to numerous communities throughout the immediate and contiguous territory.

To be specific, besides furnishing electricity to the mills mentioned, surplus current will be fed to the system of the Northern Adirondack Power Company, operating in the Ausable Valley, and this current will go to Port Kent, Ausable Chasm, Peru, Keeseville, Port Douglass, Harkness, Clintonville, Ausable Forks, Jay, Upper Jay, Keene, Keene Valley, and Wilmington. Current will also be delivered to the system operated by the Bouquet Electric Company at Willsboro, N. Y.

The undertaking comprises a dam built upstream above Rainbow Falls at a point sufficiently distant not to impair the picturesqueness of the falls. This dam, built of reinforced concrete is about 540 feet long and has a height of 20 feet. On the north side of the dam, water from the impounding area is led into a reinforced-concrete forebay terminating in a gatehouse equipped with suitable gates for regulating the flow into three associate steel penstocks. Each penstock is 6 feet in diameter and 360 feet long, and delivers water to one of three 1,500-kilowatt hydro-electric units. The waterwheels were furnished by the S. Morgan Smith Company of York, Pa., while the associate dynamos were provided by the General Electric Company.

The powerhouse is of reinforced concrete with a sharply pitched roof supported by a steel framework. This form of roof is counted upon to shed quickly any snow that may be deposited upon it. Our illustration of the plant, taken a short while before completion, suffices to show how the structure will harmonize with the natural setting. Mr. F. L. Kemp, superintendent of the J. & J. Rogers Company's mills at Ausable Forks, has thus described the manner in which compressed air has been of service on the job: "The contractors used compressed air, operating an Ingersoll-Rand compressor in all stages of the work—that is, for air drills on the masonry, and for riveting, cutting, etc., of the steelwork on the powerhouse and the penstocks."



On this loom streams of compressed air do the work ordinarily effected by moving mechanisms. A series of nozzles or tubes are placed on the loom instead of shuttle boxes, and these tubes are connected with an air line. The blasts of air issuing from the nozzles shoot the weft thread between the warp threads.

SAFETY-FIRST WORK BEARS FRUIT

THE safety campaign in the iron and steel industry is proving highly effective, according to a statement issued by the United States Department of Labor. Since 1913, in plants where continuous safety work has been carried on, the reduction in accident-frequency has been about 86 per cent., as compared to 15 per cent. in plants where no particular stress has been laid upon safety.

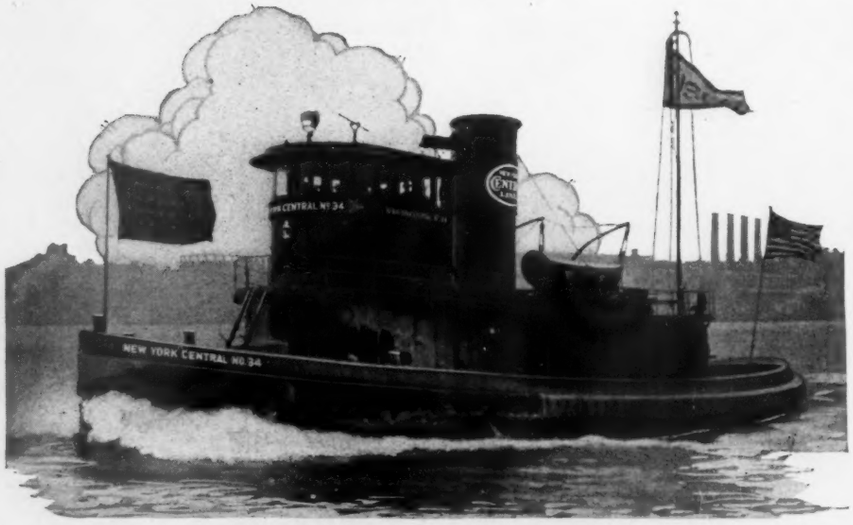
Statistics of accidents over a 16-year period up to 1926 show a gradual decline in accident-frequency during that time. Figures covering a group of iron and steel plants in which safety work has been encouraged indicate that the accident ratio for every 1,000,000 hours of workman-exposure was cut from 60.3 in 1913 to 8.2 in 1925. The group included establishments contributing approximately one-half of the output of the industry.

Because of the expansion of distributing facilities, the 984 gas companies in the United States were able to add 400,000 new customers to their lists in 1926. This is an increase of 4 per cent., and brings the total number of consumers up to 11,000,000. With a sale of 459,326,000,000 cubic feet of gas, the year just gone has been the best in the history of the industry, according to the American Gas Association.

New York Central Lines Have Powerful Oil-Electric Tug

By ALLEN S. PARK

NEW YORK Harbor has an area of 175 square miles. More freight is moved about within that harbor than is similarly handled within any other port. It is therefore but natural that intra-harbor shipping exhibits its greatest development there. Among the large handlers of harbor freight are the railroads that serve the city, and of these the New York Central Lines take high rank.



A powerful oil-electric tugboat. The stack is not required, but is retained to house the exhaust pipes from the Diesel-electric engines and to ventilate the engine-room. This tug, as well as many other vessels of the New York Central fleet, was designed by J. W. Millard & Brothers.

The excellency of the New York Central fleet of today can be attributed in some small measure, at least, to the fact that "Commodore" Cornelius Vanderbilt, the elder, bought a small sailboat when he was sixteen years old and entered the business of freighting passengers and produce between Staten and Manhattan islands. From that modest beginning he rose to a position of importance among the harbor ship operators. In after years, when his genius for railroad organization had carried him to a dominating position in the affairs of the New York Central, he very naturally turned his attention to improving the methods of handling shipments of the line within New York Harbor.

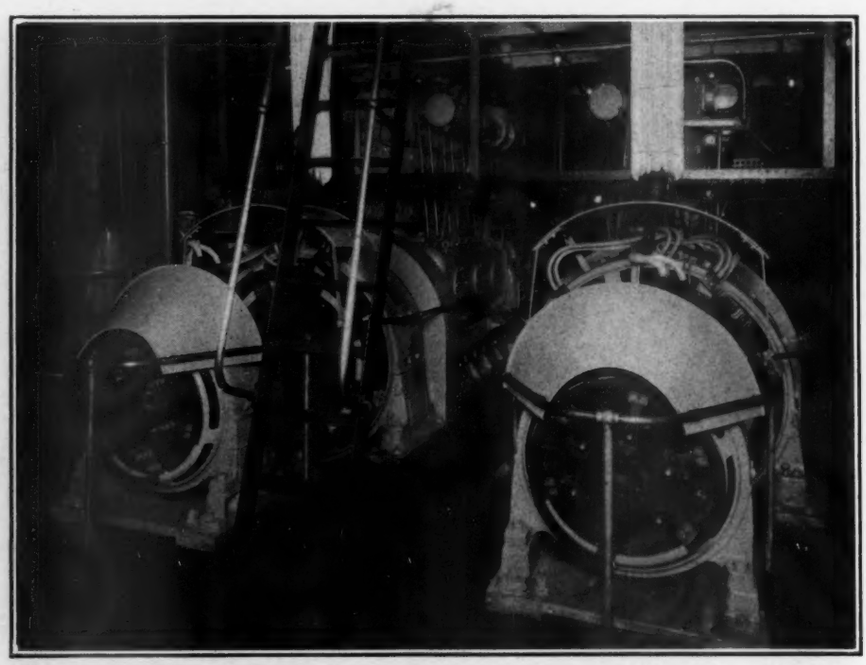
Prior to that time, the lightering and the ferrying of the company had been contracted to outside firms. In the "seventies," Vanderbilt founded the New York Central's marine department, which took over all activities incident to the handling of transportation within the harbor. Though he died a few years later, he left behind him sound ideas and farseeing policies on which his successors have built.

The harbor fleet of the system now comprises 340 craft. Included among them are 66 car floats—having a combined capacity of 884 cars, 29 tugs, 40 refrigerator and heating barges for the handling of perishable foodstuffs, 101 covered barges, 24 grain boats, 16 gasoline hoisting barges, 9 ferry boats, and a miscellany of other lighters and barges.

It is a source of pride to the marine department that its equipment is kept up to date and in condition to render the best possible service. In line with this policy, replacements and additions to the fleet are frequently made, and advantage is taken of the most recent developments in marine craft. Some three years ago, oil was substituted for coal as fuel on all steam tugs. Then, as oil engines were developed as prime movers, engines of this type began to supplant steam power plants.

The latest addition, and one that marks the dawn of a new era in harbor transportation, is the oil-electric Tugboat *No. 34*, launched in October, 1926, and placed in active service in January of this year. This oil-electric tug represents the most advanced efforts of designers, engineers, and manufacturers of its essential equipment. It combines efficiency and economy of operation.

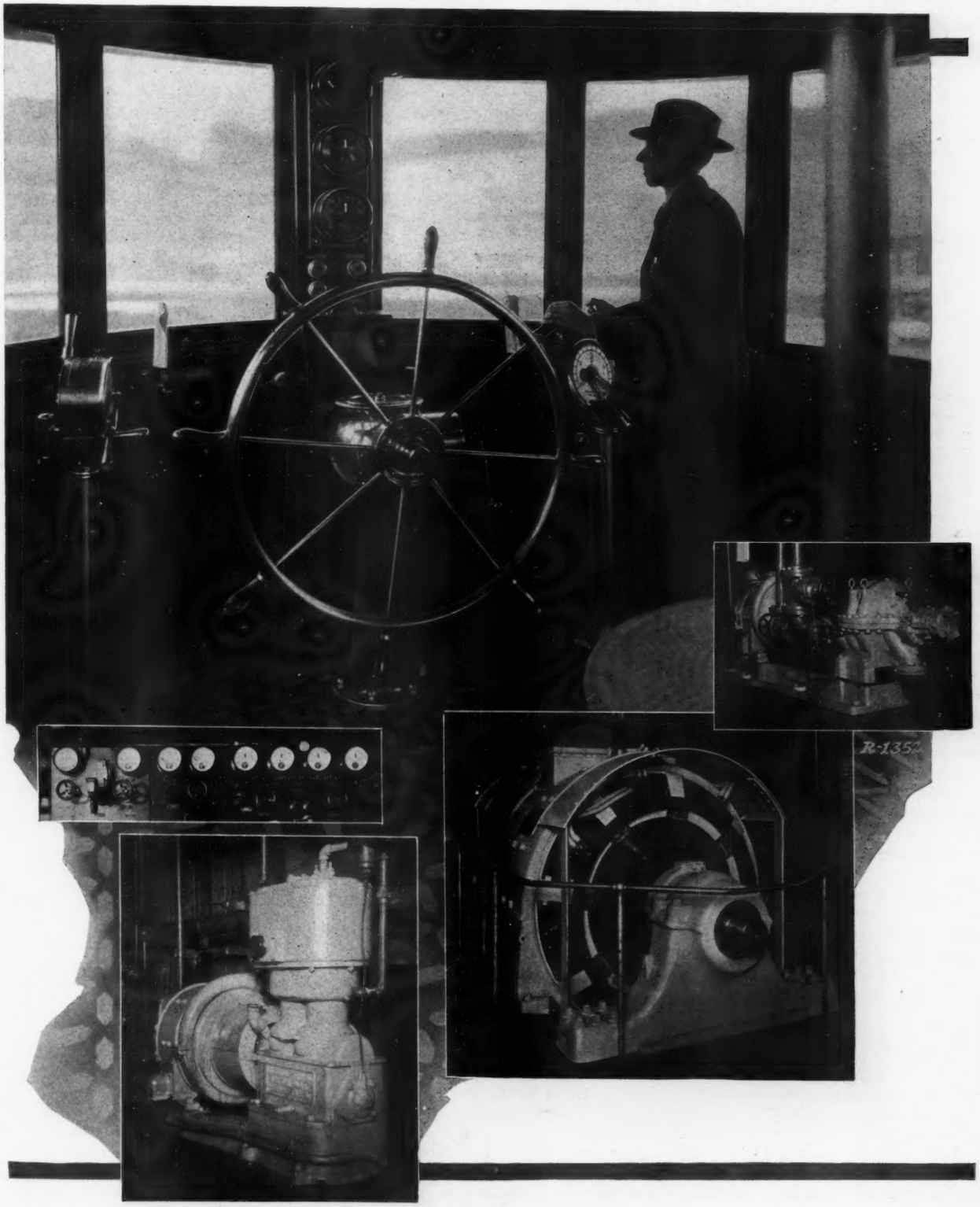
Some of its outstanding features are: low operating costs, flexibility of power; ease of handling; constant readiness for service; and freedom from dust and smoke. The annual operating expense, including interest on the investment, is approximately 20 per cent. lower than that of a steam tugboat of the same power rating. Time and labor are saved in fueling. As there are no boilers to fire and no ashes to remove fewer operators are required; and as it is not necessary to get up steam before starting the tug is always ready to go, and is available for service a greater portion of the time than is the steam tug.



General view of the engine-room, showing the exciters, the generators, and the 400-H.P. Ingersoll-Rand oil engines that drive the generators to which they are directly connected.

The *No. 34* will operate at full power for an hour on 44 gallons of fuel oil; and a fuel supply sufficient for many days can be kept aboard. Tanks can be refilled quickly and with little effort. The power plant consists of two Ingersoll-Rand Type PR, 6-cylinder, 4-cycle, solid-injection, 14x19-inch oil engines, each of which is direct connected to a 270-kilowatt General Electric

SOME PROMINENT FEATURES OF THE NEW YORK CENTRAL LINES TUGBOAT NO. 34



Top—Capt. Alex Bulson at the wheel of Tugboat No. 34 of the New York Central Lines. Observe the convenient location of the control levers and the meters.

Center, left—The set-up section of the panel board, through which various power hook-ups are made.

Center, right—Cameron pump which provides water for the boat's fire-fighting equipment.

Bottom, left—Type 20 compressor used to supply air for starting the main engines.

Bottom, right—This propulsion motor is direct connected to the propeller shaft. It delivers 650 B.H.P. when turning over at a rate of from 115 to 145 revolutions a minute.

compound-wound generator, and a 30-kilowatt exciter. Each engine develops 400 B. H. P., operating non-reversible at 265 revolutions per minute.

The fuel oil is sprayed into the center of the combustion chamber by two opposing nozzles. This results in complete atomization and thorough mixing with air. The combustion occurs without the introduction of an electric spark or of high-pressure air, being produced as the vaporized oil comes into contact with the oxygen and the heat of the air compressed in the cylinders. The simplicity and the accuracy of this combustion feature is reflected both in economy of operation and in freedom from smoke.

The generators are connected in series, and normally supply 480-volt current for the 650-shaft-horse-power, double-armature, shunt-wound propulsion motor. This motor, which is direct connected to the propeller shaft, is able to deliver full power at any speed from 115 to 145 revolutions per minute.

As the oil engines develop a constant horse power, the full power of the propulsion motor is always provided at the propeller shaft. This makes it possible to actuate the propeller with the full available engine energy, even when the tug's rate of speed is lessened by the weight of its tow. The transmission of oil-engine power through electric motors acts after the manner of speed-reducing gears. This ability to vary the propeller speed without varying the engine speed is one reason why the oil-electric method of propulsion shows such high efficiency. Such engines are lighter and occupy less space than the equipment required to deliver the same power with steam.

Either or both of the oil-engine generating sets can supply power for either or both armatures of the propulsion motor. There is, therefore, considerably less danger of paralysis of the tug. With only one of its two oil engines functioning, approximately 80 per cent. of the full speed of the tug is possible.

As the boat is entirely controlled from the pilot house, the need of signaling to the engine-room is obviated. There, the captain is literally, as well as figuratively, master of his ship. The control of the boat is as much in the helmsman's hands as is that of an automobile in the hands that hold the steering wheel. This promotes greater safety, increases the facility of maneuvering, and saves time. The possibility of damage to docks, to other craft, or to the tugboat, itself, is reduced to a minimum. As the pilot can take up the strain in the tow rope under direct observation, rope breakage is materially lessened. The *No. 34* can be turned around practically within its own length.

On either side of the electric-type steering wheel are control levers mounted on pedestals. One regulates the revolutions per minute of the propulsion motor for either backing or going ahead, and the other controls the direction of rotation of the propulsion motor. These levers are mechanically interlocked to guard against their improper use. Three meters right in front of the pilot report the electrical performance at all times.

All the engine-room auxiliaries are driven by motors. The power is supplied, through the various switchboard combinations, by take-offs from the exciters. The oil engines are started by compressed air. This is furnished by an I-R Type 20 compressor direct connected to a 12-H.P. motor. This machine delivers air at 250 pounds pressure to two tanks, each of which has a capacity of 25 cubic feet. The motor is automatically shut off when the tank pressure reaches 250 pounds. A 4-kilowatt, 120-volt, direct-current generator, driven by a 6-H.P. Diesel engine, furnishes power and light for stand-by service. It is also connected through a clutch to an I-R Type 15 compressor which charges the tanks supplying air for turning over the main engines in case of emergency.

The boat is equipped with fire-fighting apparatus consisting of a 1,700-revolution-per-minute Cameron, multi-stage centrifugal pump, having a capacity of 500 gallons per minute against 150 pounds discharge pressure. Water for three nozzles is supplied by this pump. A 20-H.P. service pump has a capacity of from 200 to 400 gallons per minute against a 30-foot head. Its variable speed control enables it to be operated at reduced speed for bilge work, or at maximum speed for pumping out barges, etc. Other auxiliary units are: two circulating water and bilge pumps, a fuel-transfer pump, and a steering motor. An oil-burning furnace is used for heating the pilot house, engine-room, and crew's quarters.

The *No. 34* has a length of 108 feet 3¼ inches, has a width of 26 feet, and a draft of 9 feet. It was designed by J. W. Millard & Brothers, and was built and outfitted by the Staten Island Shipbuilding Corporation. In order that persons connected with or interested in transportation in the Port of New York might observe the tugboat in operation, the Ingersoll-Rand Company, through the courtesy of the New York Central Lines, recently conducted a series of short cruises about the harbor. Prominent designers, builders, and operators of harbor craft were in attendance.

CHICAGO GOOD ROAD SHOW

NEARLY 25,000 persons viewed the latest types of roadbuilding equipment exhibited at the Road Show held recently in Chicago in conjunction with the annual convention of the American Road Builders Association. The Coliseum and four other buildings housed the displays of machinery, valued at more than $3,000,000—the products of 300 manufacturers in all sections of the country.

The accompanying illustration shows the exhibit of the Ingersoll-Rand Company, which evoked much favorable comment. A feature of this display was an I-R No. 33 sharpener which was utilized to show the making of drill steels from bar steel and the reconditioning of used drill steels.

Ingersoll-Rand roadbuilding equipment shown at the Chicago Road Show.

A block of Tennessee granite in the booth served to demonstrate the drilling speed of the R-12 model "Jackhamer." Other working exhibits of this company were a pneumatic lumber saw and a small Cameron pump designed to meet the needs of the roadbuilding contractor. A Type 20 portable compressor was prominent among the displays, which also included other miscellaneous equipment of interest to highway builders.

More than 1,000,000 persons are employed in the United States in roadbuilding. This is a far larger army than that engaged in either the automobile or the steel industry.

Strip Coal Mining With Liquid Oxygen

In Clearing Away Overburden This New Explosive Has Proved Very Efficient and Economical

By EUGENE SHADE BISBEE

LIQUID oxygen as a superior explosive is now being used in the mining of coal, its applicability having been demonstrated and its effectiveness thoroughly established. First in the United States to make use of this new medium in coal mining is the Enos Coal Mining Company. Operating under the vivid personality of George A. Enos, president, of Cleveland, Ohio, these strip coal mines have been continuously exploited ever since the first blast opened up the great veins of bituminous that underlie a large part of the farming land in the lower end of Indiana.

Though the romance of coal mining may have lost some of its glamour in this age of invention and intensive production, the demand of the world for fuel is insistent; and, in this instance, great areas of coal stripping lands are being steadily developed in the territory to which reference has been made.

To the average person, a coal mine is a deep hole in the side of a hill or a mountain, with labyrinthine passages, little mule-drawn cars, shafts of great depth up and down which rush elevators, while in the murky holes beneath the mountain, grimy men, with torches on their foreheads, ceaselessly toil with pick and shovel, day and night, year in and year out. There is a deal of truth in this picture, for the old anthracite mines of Pennsylvania and the extensive bituminous fields of other sections have all these characteristics. So intensive has been this work of digging coal that not infrequently portions of towns overlying such mines have been engulfed because of the removal of their natural foundations.

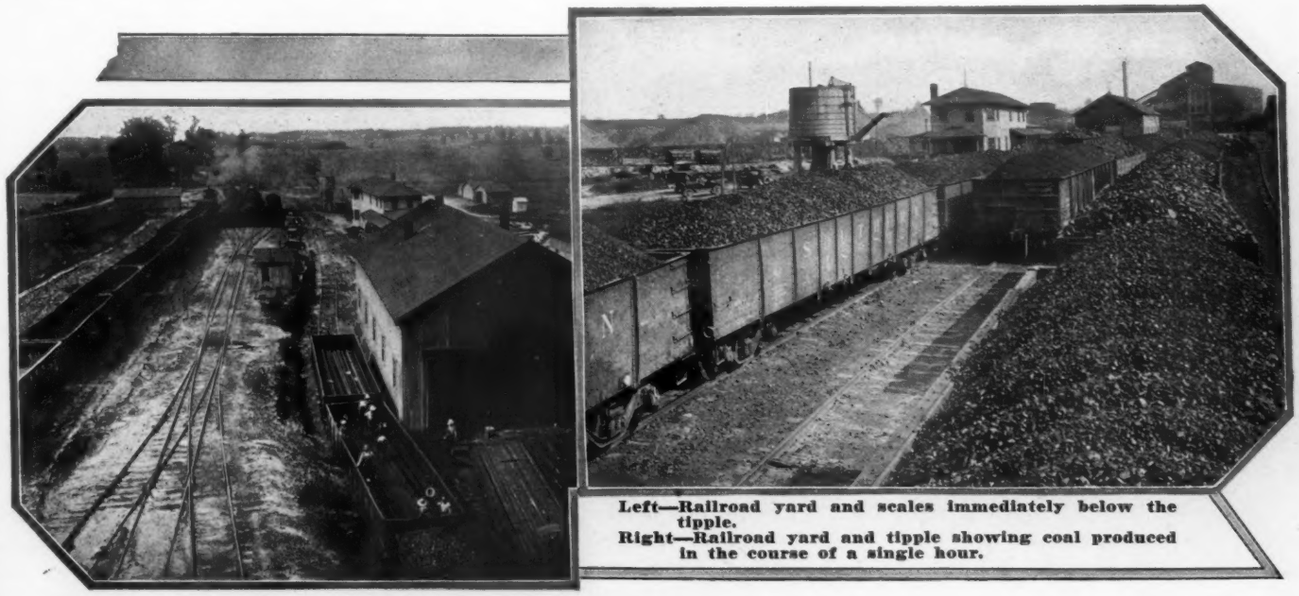
But there is another kind of coal mining—one in which there are no shafts, no mules, no tunnels, none of the unpleasant features of the others that burrow for miles beneath the crust of the earth. This is known as "stripping," and is merely the removal of the uppermost strata of earth and rock and uncovering the vein of coal, which may then be broken down and loaded out as desired. Mining in this fashion is carried on in those districts where the veins lie near the surface—the general thickness of the overburden to be considered in this case being from 25 to 35 feet, while the vein of coal is from 5 to 7 feet thick.

The "strip" mines of the Enos Coal Mining Company are being operated on an ever-increasing scale; and more land is being acquired for their further development. At present there are about 5,000 acres under the control of the company—formerly farming land covering almost ten square miles, beneath which lie, according to estimates by engineers and geologists, many millions of tons of high-grade fuel, enough to keep a large force of men at work for years. The beds have been commercially operated since 1921, the output for the last calendar year having been in excess of 800,000 tons for four complete units, while a fifth unit, to be added during 1927, will bring up the annual production to 1,250,000 tons. Drill tests over a comprehensive territory have indicated a vast field of high-grade coal. Analysis has shown that the coal has from 13,700 to 14,000 B.T.U.'s; and it burns with a surprising freedom from clinkers.

The overburden covering the coal is composed of varying strata, some of which are so hard that the big steam shovels cannot dig them in their natural state. It is therefore necessary to loosen this overburden with explosives so that the dippers on the shovels may easily penetrate it. This loosening process consists of drilling 6-inch well holes from the surface to a point about 1 foot above the top of the coal vein. These holes are drilled on approximately 18-foot centers. They are then charged with the new explosive, the accepted abbreviation for which is L.O.X.

The liquid oxygen used in the making of L.O.X. is produced by the Claude process of liquefaction, the American rights for which are held by the Air Reduction Company. The explosive is now doing excellent work at the mines of the Enos Coal Mining Company. L.O.X. is a combination of liquid oxygen and carbon—the carbon being saturated with the liquid oxygen in forming the explosive L.O.X. Briefly stated, the necessary liquid oxygen is the result of alternate compressing and expanding of air; and when atmospheric air is thus liquified then the oxygen and the nitrogen of the air are separated by a system of fractional distillation.

Each L.O.X. cartridge used by the Enos Coal Mining Company consists of a cotton bag, 18 inches long and having a diameter of 4½ inches, which is filled with a suitable form of carbon. A number of these cartridges is then placed in a "soaking box" and submerged in liquid oxygen. Each cartridge absorbs about 3½ times its own weight of the liquid oxygen; and the cartridge, when ready for use, weighs about 13 pounds. These cartridges are hauled to the pits in the soaking boxes; placed in the well holes; and detonated in the usual manner



Left—Railroad yard and scales immediately below the tipple.
Right—Railroad yard and tipple showing coal produced in the course of a single hour.

Steam shovel clearing away the blasted overburden.

with Cordeau-Bickford. L.O.X. has a much higher rate of detonation than black powder or dynamite and, as a consequence, the shattering effect exerted by it on the rock is much greater.

In summing up the advantages of L.O.X., it has been practically demonstrated that it is cheaper by about one-half than black powder or dynamite; it is much safer to handle; and it prepares the overburden so much better that the shovels can dig it more rapidly, thus resulting in a greatly increased efficiency in production.

The terrain encompassing the Indiana fields is of attractive aspect, rolling land with here and there clumps of trees. It was about a generation ago that this coal field was discovered on the Stevens farm in Pike County, southern Indiana, where the coal was dug and used for purely local consumption. Primitive were the methods in the early days of getting at the coal, yet the neighbors had all they wanted; and the fuel proved of such superior heating power and was so free from clinkers in its burning that it was exhibited at the county fair every year and never failed to win first prize over its competitors from Kentucky, West Virginia, and Ohio.

Steam shovel loading side-dump cars with coal.

Its discovery came about through the digging of a well for water. After sinking a shaft through the first few feet of arable soil, the diggers found a hard stratum of rock. Through this they bored; and the coal vein, itself, was entered at a depth of about 25 feet and was found to be from 5 to 7 feet thick. Tests proved it to be of high grade, yet the outside world beyond the borders of Pike County paid little attention to the find, so extensive were the fields elsewhere, and there being at the moment no demand for more coal.

Before the existence of the beds in southern Indiana was known, the residents who lived right on top of the millions of tons of splendid coal had been deriving their winter supplies from neighboring states. With the discovery, every farmer in the region began digging coal on his own property, inaugurating what was the only self-sustaining communal district in this country. Not a resident of the region found it necessary to send out of the district for any essential, with the possible exception of manufactured iron and cotton goods. They had wool from their sheep and timber from their lands; fruits from their orchards; beef, pork, and mutton from their herds; and vegetables and cereals from their gardens and fields. In those golden pre-Volstead days they had, too, an abundance of corn and rye which they could exchange with the Blue Grass State for good liquor distilled in that fair land. With the production of coal, their lot was indeed to be envied.

But eventually the outside world took notice of this latent fortune awaiting the industrial call. Word of it came to the attention of George A. Enos, who got extremely busy. Mr. Enos is young in years but old in experience. There was nothing speculative about his entry into the Indiana field. He had consultations with and advice from competent engineers and practical coal miners. The work of the Enos Coal Mining Company has always been systematized to the last degree; and, today, the books will disclose exactly where every ton of the output has gone and what has been the net profit.

It was learned at first that it would be necessary to acquire a vast territory before operations could begin even on a small scale. By careful purchase, this was accomplished. Farm after farm was bought; and, wherever possible, adjoining land was purchased so as to make the entire property coördinative. Following this, it was found that there would have to be built about 8 miles of standard-gage railroad trackage, including yardage and switches, in order to bring to the field the cars of the Big Four and Southern railroads, each of which was within easy reach and had to be tapped to transport the product of the mines. The cost of this was estimated at about $250,000, which was supplied through the activities of George Enos. Then came the cost of the plant, which called for a very large sum, and this also was forthcoming through the same agency. In October, 1921, less than five months after work on the equipment was started, ship-

1—One of the big steam shovels employed in stripping the overburden from the coal.
2—Smaller steam shovel loading cars with coal.
3—A bucket that picks up 7 cubic yards of coal at a load.
4—Coal being screened and separated into different sizes.
5—Run-of-mine coal loaded for distant delivery.

Liquid-oxygen containers, cartridges, and soaking box.

ments of coal began to stream from the mines, and these have grown steadily in volume ever since.

An interesting description of the Enos property and its functioning was recently given the writer by Fred S. McConnell, vice-president and general manager of the company, who is also authority for the figures regarding present and prospective output of the mines as well as for the other technical details throughout the story.

"The overburden covering our coal," said Mr. McConnell, "contains strata of very hard materials, such as shale, rock, and the like. It is necessary to shatter these strata by blasting in order that the steam shovels may dig it. The ordinary way to break this material is to drill well holes of about 6 inches diameter from the surface of the ground down to the coal itself. These holes are then charged with either dynamite or black powder and, in conjunction with other holes similarly charged, are shot and the overburden broken.

"In an endeavor to reduce costs, we put ourselves in touch with recent scientific investigation in our search for an explosive which would be cheaper and more effective than either black powder or dynamite. This search revealed that the Air Reduction Company was conducting exhaustive experiments with liquid oxygen as an explosive.

"In the Spring of 1926 we purchased a plant from that company, and in the following May commenced making and using liquid oxygen at our plant in Oakland City, Ind. Our experience with this plant has been very satisfactory, indeed; and the use of liquid oxygen has resulted in very considerable direct savings to our company as well as in indirect savings which are very hard to measure. A completed liquid-oxygen cartridge, weighing only about 13 pounds, will do the blasting work of a keg of black powder, which weighs 25 pounds and costs a good deal more.

"The liquid oxygen shatters the overburden much better than did the powder. This has enabled us to equip our shovels with dippers one cubic yard greater in capacity than those formerly used by us, with a consequent increase in efficiency. Even with this increased dipper capacity the strain on our shovels is much less than formerly on account of the better broken condition of the bank. This, we feel, will result in considerably decreased repair bills.

"For drilling the coal we use air compressors with Jackhamer drills. The coal has to be drilled and shot so that the loading shovels can pick it up. For this purpose we have portable compressors."

The work of uncovering the coal veins, of sweeping them clean, of picking up the raw material, and of loading it on to the small cars that carry it to the screens, tipple, and graders, whence it finally reaches the gondolas of the Big Four and Southern railroads, is an interesting story of the efficiency and the energy of modern methods and means that make for quantity production at a considerable reduction in the waste of material and power.

In first loosening the overlay, well holes are drilled to within a foot of the vein of coal. These holes are then filled with L.O.X. cartridges, which are detonated simultaneously. The resulting explosions thoroughly disintegrate the overburden and break up into small particles the hard rock above the coal, making it easy for the shovels that follow to remove the material and to uncover the vein.

The stripping shovels are operated by steam or electricity, are mounted on caterpillars, and each has a capacity of from 7 to 9 tons per bite. Swinging about on 55-foot dipper sticks on 90-foot booms, the shovels move the loose earth and rock aside, laying bare the coal vein. The dippers are of 7-cubic-yard capacity, and each bite takes forty-five seconds from start to deposit of its load on the bank above the cut. As the shovels move along in removing the earth and rock from the vein, gangs of sweepers, with brooms, follow and clean the vein of every particle of foreign material. This leaves a smooth floor of jet-black coal exposed for breaking up by drilling and blasting—the coal being too hard, as already mentioned, for the car-loading dippers to tear up.

When the vein has been drilled and shot, the "black diamonds" are piled in great masses at the end of the ledge. It is then that the dippers get busy. Standing on its narrow-gage track above the open cut is a train of ten cars waiting to be filled. At its working speed of one mouthful every forty-five seconds, the big dipper loads this train in about eight minutes, when it scurries away to the tipple plant where the coal is further cleaned

A car partly filled with lump coal ready for shipment.

and graded before being finally carried to the trunk lines for hauling to its destination.

As the carloads of coal reach the tipple the material is apparently clean but of varying sizes. Yet it still contains much foreign matter that must be removed, according to the standards of the Enos Coal Mining Company. The tipple, itself, is about the neatest thing ever seen at a coal mine. Neatness seems to be the watchword of the system; and every operative takes pride in his personal appearance as well as in keeping impurities from the coal as it passes through the grading machinery.

At the tipple, an inspector views carefully every car that comes for unloading—and its contents must be coal and nothing else, or back it goes. His assistants see to it that anything that he may have overlooked does not get past them, it being impossible for one individual to critically inspect with infallible eye an entire trainload. So when the coal is finally deposited on the Link-Belt machinery, with which the plant is equipped, there is not much uncertainty regarding its quality. The machines, themselves, do the grading—every lump going into its correct chute for deposit in an associate receptacle beneath.

Mechanically propelled, the coal, in mass, is fed over the screening tables for assortment into varying sizes. Men stand at the tables and, as the lumps of coal pass, look out for impurities—removing everything but coal of standard grade. The product finally goes into the loading boom and thence to the cars that convey it to the temporary storage depots in the yards.

NEW BRIDGE TO SPAN ST. LAWRENCE

PLANS for a new international bridge to span the St. Lawrence River near Brockville, Ont., on the Canadian side, and Collin's Landing, N. Y., on the American side, have been announced by the Ottawa Board of Trade. The structure is to be built at a cost of about $6,000,000 by private enterprise.

The bridge will be in three sections, of which the first—650 feet long—will rest on Wellesley Island. Next, 4½ miles of motor highway will lead to the second section that will cross over what is called the rift and the international boundary to the Canadian part of the island. Thence, the mainland of Canada will be reached by way of the third section, which will have a span of 550 feet.

To open up 3,000 square miles of new trading territory and at the same time to provide a shorter route to the east for the coal and other products of southwestern Saskatchewan and southern Alberta, a double-deck highway and railway bridge has been built across the South Saskatchewan River near Dunblane. The top deck carries the railway track of the Canadian National Railways and the lower deck is for motor traffic. This steel-and-concrete bridge is 1,771 feet long and consists of ten spans.

Compressed Air Reduces Torpedo Losses

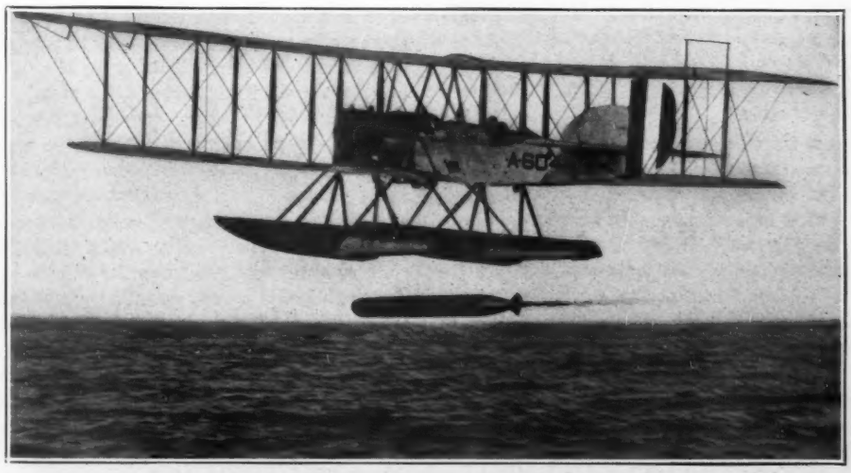
THE modern automobile torpedo is the climax of many years of inventive effort and the studious exercise of much engineering skill. The utmost precision is required in manufacturing these underwater, self-propelled projectiles, which carry in their war heads large charges of a high explosive. These miniature submarines start on their errands of destruction at a speed of approximately 50 miles an hour; and under the impulse of compressed air they will continue on their course for a number of miles. Compressed air serves not only to drive the propelling mechanisms but it also actuates the servo-motors that control both the vertical and the horizontal rudders, which guide a torpedo toward its target and keep the missile submerged at a virtually uniform depth while making the run. Each torpedo costs several thousand dollars.

Torpedoes are launched at stated times each year during target practice so that the torpedomen may be made thoroughly familiar with their handling and adjustment and that they may become qualified marksmen. Manifestly, it is important that every care should be exercised to recover a torpedo launched upon a practice run. Occasionally, a spent torpedo will dive and bury its nose in the water bed; and then much time may be consumed in an endeavor to locate and to recover it. These efforts are now and then without avail. Therefore, the torpedoes are fitted frequently with a calcium phosphide torch which emits a flame at night and generates smoke which is visible in the daytime—provided the torpedo floats at the surface of the water at the end of its run. This torch makes it relatively easy to discover the whereabouts of a spent torpedo and to pick it up.

To lessen the likelihood of a torpedo going to the bottom during a practice run and to make it still more visible when its run is finished, the Bureau of Ordnance of the United States Navy Department has devised an air-blowing head. For target practice, each torpedo is equipped with a dummy head in place of the war head with its charge of high explosive. The exercise head is filled with sufficient water to compensate for the weight of the absent explosive. This arrangement gives the torpedo that very nice balance which is needful to make it perform as desired. The purpose of the air-blowing attachment is to expel the water in the head at the proper time so as to give the torpedo added buoyancy that will make the torpedo stand up on end and hold its head well above the sea surface.

The device consists principally of a spring-loaded valve which seals the chamber in the exercise head against the pressure of the air in the main air flask. When the pressure in the air flask drops to a predetermined point—as it would after the torpedo had gone a prescribed distance—the spring opens the valve and allows the air to enter the exercise head and thus to force the water out of the head, thereby giving the torpedo increased buoyancy that will make the weapon float upright.

The Navy Department is now issuing this pneumatic attachment to our fighting fleet; and it is hoped that this auxiliary will greatly reduce the number of torpedoes annually lost during target practice. Not only are many of the ships of the battle fleet equipped with torpedo tubes but, thanks to the pioneer work of Rear Admiral Bradley A. Fiske, we now have torpedoplanes that are capable of carrying and launching torpedoes while in flight. These planes add greatly to the torpedo's field of offensive usefulness and, conversely, the torpedo increases the military value of the naval seaplane.



U. S. Naval Torpedoplane launching an automobile torpedo while in flight. The streak behind the torpedo is compressed air exhausted by the propelling mechanism.

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EDITORIALS

HUDSON BAY MAY HAVE A GRAIN PORT

SHORTENING the road to market is one sure way to reduce handling costs and, incidentally, a means to prompt disposal of commodities at a profit. It is this urge that lies back of the efforts to convert the St. Lawrence into a shipway that will link the Great Lakes with the Atlantic. Similarly, every now and then, the proponents become vocal in behalf of utilizing Hudson Bay and Hudson Strait as an outlet for American grown grain bound to Europe. Heretofore, little more than talk and some surveys have been indulged in, although the Canadian Government has shown an intermittent disposition to help along some of the projects already outlined. Now, according to the *New York Times*, the subject has been revived and steps are to be taken looking to the creation of a port on the southern shore of Hudson Bay that shall be linked by rail with such shipping points for grain as Port Arthur and Fort William on Lake Superior.

A brief glance at an atlas will disclose that Hudson Bay—assuming that it is open to traffic long enough to warrant the establishment of a grain port on its south or western shore—offers a notably shorter route for steamers bound to and from the British Isles or neighboring continental Europe. According to accepted authorities, Hudson Bay is sufficiently free of ice for five months each year to permit the maintenance of such a route. The principal stumbling block to the consummation of any of the plans hitherto proposed has been the cost of constructing the needful connecting railroad. Furthermore, there have been some political and promotion aspects to these schemes that, sooner or later, have brought them into disfavor. The Canadian Government has pretty generally been expecting to supply a goodly part of the necessary money.

At the present time, the preliminary investigating has been assigned to FREDERICK PALMER, consulting engineer of the ports of London and Glasgow, and now retained by the Dominion Government—and to Capt. J. E. BERNIER, a man of exceptionally ripe experience in the navigating of northern and Arctic waters. Not only to the people of Canada, and especially to those of Western Canada who are desirous of having at their disposal a shorter haul to salt water, but to all those dwellers in the states contiguous to the Great Lakes, who have so vigorously advocated the St. Lawrence shipway, the prospective report of Messrs. PALMER and BERNIER will prove extremely interesting. The engineering fraternity at large will also watch the outcome not only because of the importance of the scheme in certain of its construction features, but because of the fascinating character of the subject which has long appealed to the imagination. Nature will interpose difficulties that will call for courage and resourcefulness on the part of any men that tackle the problem.

NEW CASCADE TUNNEL

SEATTLE, within the span of a single generation, has expanded by leaps and bounds until it is now a metropolis of 400,000 people. Within the same comparatively short interval that city has become the commercial, the industrial, the distributing, and the maritime center of the Pacific Northwest of the United States.

In this truly amazing development, the tributary railroads have played a big part, and none a more important part than the Great Northern Railway. That enterprising line surmounted the Cascade Mountains in order to give to Seattle the service it sorely needed so as to make the most of the city's outstanding physical and geographical advantages.

Railroadmen are familiar with the staggering difficulties with which the Great Northern had to contend when it carried its tracks up over Stevens Pass in the first place; and they are equally aware of how the road has spent millions of dollars in driving tunnels and in building snowsheds to sidestep or to minimize the effects of the heavy snowfalls that cloak the pass and its approaches during the wintertime. Now, to make faster time through the Cascades and to escape most of the hampering effects of the regional snowfalls, the railroad is driving a tunnel nearly eight miles long right through the mountains that will lower the climb by half a thousand feet and shorten the run from side to side of the pass by substantially eight miles. In the prosecution of this monumental undertaking a premium is placed upon speedy consummation—the railway counting upon saving substantially a million dollars annually through the medium of the modified route.

In the present issue, we begin an article dealing with this new tunnel through the Cascade Range; and the text will reveal facts illustrating the tremendous progress that has been achieved in recent years in devising drills that can penetrate the hardest rock rapidly and in developing mucking machines that can speedily handle the blasted rock and promote its quick withdrawal to the dumps. Not only that, but the text will also show how skillful organizing of men and machinery has made exceptional progress records possible. Nowhere at any time have crews achieved in the course of a month the footage records made by the drill runners and muckers on the new Cascade Tunnel. These records are, undoubtedly, in large measure due to the spirit that has inspired the men at the headings—a spirit that has made of hard and difficult work a contest filled with the urge of true sportsmanship.

NEW AIDS TO THE MARINER

MEASURING the sea's depths by timing the interval between the generation of a sound and the returning echo from the waterbed bids fair to place the sailor's lead line among the things that once served the navigator. The sonic method of sounding is no longer in the experimental stage—the system has been perfected and is now utilized aboard a considerable number of craft.

Now, the man on the bridge has another aid to guide him away from danger in the form of a hurricane or of a kindred intense atmospheric disturbance. Static, which has so persistently bothered the wireless operator, can today be used to give warning of the proximity and of the direction in which the center of storms of this nature may be moving. This development is directly due to the fact that operators, aboard the U. S. S. *Kittery*, discovered that interference due to static was always intensified when a tropical storm swept across the path of wireless communication; and the degree of this interference was found to be a reasonably accurate gage of the nearness and the severity of the hurricane. By checking up the direction in which reception was thus impaired, it became a fairly simple thing to establish the position of the storm center. Recording instruments are now in process of development that will automatically register the disturbances and indicate rapidly the location and the general character of the atmospheric perturbation.

NEED OF UNIFORM TRAFFIC REGULATION

DURING the last calendar year, a total of 6,649 persons died as a consequence of automobile accidents in 78 of the country's large cities. This record is both distressing and appalling. At the moment, no details are available that will reveal the principal causes of this mortality; but it is reasonable to suppose that a considerable percentage of the deaths was due either directly or indirectly to confusion or mistakes arising out of misunderstood traffic signals.

It is not necessary for the motorist to drive throughout the length and the breadth of the land to have brought home to him the sorry

lack of uniformity in the signaling systems employed in different communities and even in different parts of some of these communities. The gravity of this state of affairs is, of course, inevitably intensified whenever the volume of traffic becomes dense. Furthermore, hazards multiply when dependence at intersecting busy thoroughfares is placed upon automatic signals rather than upon an alert and adaptable traffic officer.

In some cities, a 2-color light system of traffic signals is employed, while in others a 3-color system is in vogue. The 3-color system, while theoretically desirable because the white or the yellow light is generally used as a cautionary or preparatory signal, leads to trouble because drivers and pedestrians all too frequently accept it as permission to go ahead athwart the still moving traffic current traveling at right angles. Again, in one large city, the white light in some parts of that city is authority for cars to advance and to turn into traffic, while in still other sections of the town such turns are allowed only while the red or stop light is displayed. The visiting motorist is likely to be unfamiliar with this dual system of control. Futhermore, in many communities, right and left turns into traffic are permitted when the stop light is shining, while in other nearby communities the stop light calls for a complete cessation of movement on the part of the arrested traffic line. These variations in practice occasion trouble with more or less frequency; and the seriousness of the trouble grows directly with the increased volume of traffic that may be obstructed at a critical moment just when the authorized tide is advancing rapidly.

If the regulation of motor traffic were a purely local problem in every instance, there would be no warrant for criticism. But pleasure cars, business cars, motor trucks, and buses now travel long distances and run through many communities en route. This makes it imperative, in the name of public security and safety in transit, to devise a uniform system of traffic regulation and to enforce it everywhere. The sooner this is done, the better; and as soon as it is done there will, undoubtedly, be a marked reduction in the number of accidents that cause serious injuries and, possibly, deaths.

Two interesting mineral finds in Newfoundland, made almost simultaneously late last year, show promise of becoming profitable producers, so it is reported by the United States Trade Commissioner at Ottawa, Canada. One of these, at Red Indian Lake, is a massive sphalerite galena ore body yielding 20 per cent. zinc, 15 per cent. lead, and some gold and silver. This property is now being exploited; and 400 men are to be employed there this spring when actual mining operations are begun. The other is a strike of lead, at Le Manche. Exploratory work has revealed that the vein varies in width from 3 to 10 feet and averages from 6 to 15 per cent. lead ore. This deposit is also undergoing development.

PAINTING BY IMMERSION AND BY COMPRESSED AIR, by A. Seymour Jennings. A copiously illustrated volume of 272 pages, published by The Trade Papers Publishing Company, Ltd., London, England. Price, $3.00.

IT has been clearly demonstrated in recent years that paint may be applied either by immersing an article in a paint-filled tank or by spraying the paint onto the surface of the article with the aid of compressed air—in either case obviating the use of the familiar paint brush. The rapid adoption of both processes is due in the main to the immense savings in time thus made possible; and, broadly stated, the time reduction may be anywhere from one-half to nine-tenths. The cost of application is lowered proportionately.

In the accompanying book the author describes many of the ways in which the two processes are utilized; and he shows in detail the different apparatus and equipment required. We believe that Mr. Jennings' book will prove valuable to a large circle of interested persons.

OIL ENGINE POWER PLANT HANDBOOK. An illustrated work of 244 pages, edited by Julius Kuttner, Roswell H. Ward, A. B. Newell, and J. Holley. Published by Oil Engine Power, New York City. Price, $5.00.

THIS is the second edition of the work, which is a compilation of articles issued from time to time by *Oil Engine Power*. The subjects covered are varied and sufficiently comprehensive and authoritative to make the handbook a welcome addition to the library of anyone that has to do with the modern oil engine in its diversified fields of service.

PATENTS, by Roger Sherman Hoar, Head of the Patent Department of the Bucyrus Company. A book of 232 pages, published by The Ronald Press Company, New York City. Price, $4.50.

THE purpose of this book is to furnish guidance to business executives that may have reason, for one purpose or another, to consider patents and who should then have some broad understanding of the subject so that they may make business decisions affecting the patents coming within their cognizance as business officials.

As the author explains in the opening paragraph of his preface: "This is the age of invention. The Patent Office at Washington is grinding out patents at the rate of nearly a thousand a week. There is hardly an industrial, or even mercantile concern in the United States, which is not likely to find its entire status altered over night by the issuance of some patent to it or to one of its competitors. Hardly a week passes without its executives being called upon—or, if not, they ought to be called upon—to decide some question of patent policy." The book is intended to help these business heads to arrive at a correct decision.

MISSISSIPPI STEAMBOATIN', by Herbert Quick and Edward Quick. An illustrated volume of 342 pages, published by Henry Holt & Company, New York City. Price, $3.00.

THE authors have done a real service by bringing together the really fascinating facts that they have in connection with steamboating on the Mississippi—covering, especially as they do, the days when power-driven craft on that great stream played a truly vital part in developing certain sections of the country and in promoting intercourse and the exchange of commodities.

The period was a picturesque one, and filled with thrills and many deeds that ranged all the way from calculating caution to reckless bravery. Steamboating then was full of hazards that developed a peculiar type of skipper and associates. Life afloat upon the Mississippi and its tributaries was colorful in the extreme; and, knowing what conditions are in kindred services today, we look back at the period covered by the authors and marvel. The river steamboat filled a peculiar and a memorable place in our national development, and how valuable that place was most of us are unaware. The book will furnish delightful entertainment while providing a fund of information.

THE MATHEMATICS OF BUSINESS, by Prof. William V. Lovitt and Prof. Henry F. Holtzclaw. A volume of 246 pages, published by D. Appleton & Company, New York City. Price, $3.00.

THE object of this book is to aid persons intent upon becoming acquainted with the elementary principles of mathematics as applied especially to problems arising in the business or financial world.

The authors have studiously tried to avoid technical language and have dealt with their subject as far as practicable in the simplest terms consistent with exactness and clearness. They have succeeded admirably in their undertaking, and they have produced a work of much potential usefulness.

COMMERCIAL AIR TRANSPORT, by Lieut.-Col. Ivo Edwards and F. Tymms. An illustrated work of 163 pages, published by Isaac Pitman & Sons, New York City. Price, $2.50.

THE subject is covered especially from a British viewpoint, and what air transport has to offer Great Britain. While considered in this way, still the facts brought out in the handling of the subject by the authors are of value to other nations confronted with the same problem of adapting aerial transportation to their purposes.

The authors have done more than to merely present accumulated data and experience in the application of aerial transportation to everyday services—they have added to the pleasure-giving angle of their subject by a pardonable play of imagination. The book is interesting and authoritative.

Cameron Single-Stage, Double-Suction, Volute Centrifugal Pumps is the title of a booklet recently issued by the Ingersoll-Rand Company, 11 Broadway, New York City. A copy of this bulletin can be obtained gratis upon application by anyone interested in the use of pumps.

Nickel Steel Data and Applications is the title of nine bulletins issued by The International Nickel Company, 67 Wall Street, New York City. These bulletins contain much useful and valuable information, and copies of them can be obtained free upon request.

GASOLINE SUBSTITUTES

MATERIAL progress is reported from France in the development of motor fuels other than gasoline. Efforts of French scientists in this field are summarized in a recent report by the United States Department of Commerce. Developments to date have been along three principal lines: first, the building of ganzogene generators utilizing wood and charcoal; second, the making of low-price alcohol; and, third, the production of synthetic petroleum.

To demonstrate the practicability of ganzogene generators, La Société Berliet, French manufacturers of automobiles, established a free touring-car service between a Paris garage and an automobile show held at the Grand Palais. These cars bore signs reading, *Sans Essence*—meaning, without gasoline; and attracted wide attention.

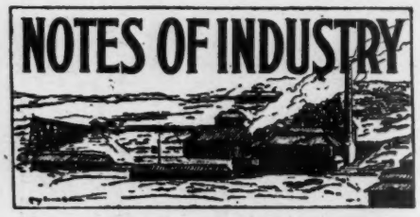
Louis Pianeau, director of the national office of liquid combustibles, is credited with the statement that, for heavy vehicles, the operation of ganzogene generators is now an accomplished fact. It is claimed that a car so equipped can be put in motion within 3 or 4 minutes, and that the economy thus effected, as compared with gasoline, reaches 80 per cent. The generators are not, however, suitable for light cars.

Research has established the fact that alcohol is a desirable substitute for gasoline in touring cars. But, owing to its scarcity and high price in France, the problem there is one of developing new sources of supply. As it has been determined that the agave, a tropical plant, lends itself to the production of rope and twine, with alcohol as a by-product, the culture of this plant is being encouraged in the French provinces of Algeria and Senegal.

It is claimed, and the claim is at least partially supported, that synthetic methanol has been produced in the laboratory, though it is admitted that the application of the process on a commercial scale is a problem yet to be solved. The process consists of playing water upon coal in ignition to produce hydrogen and carbon monoxide, and these gases are then subjected to high pressure and high temperature and directed upon a catalyst.

Of the 10,000,000 homes in Great Britain, approximately 1,400,000, or 14 per cent., are wired for electricity, as compared with 26,000,000 dwellings in the United States of which 14,500,000, or 55.8 per cent., are lighted electrically.

It is officially reported that 1926 has shown the highest total production and consumption of industrial commodities of any year in the history of the United States.



The world over, there is one automobile for every 71 persons. By way of contrast, the ratio in the United States is as 1 is to 6, while in Afghanistan there is but one automobile to each 1,200,000 inhabitants.

Statistics have it that the railroads of the United States disburse more than $320,000 every sixty minutes for wages and in excess of $42,000 hourly for fuel, material, and supplies.

If all the oil wells drilled in the United States in 1925 were placed end to end, they would form one great well 13,000 miles deep—a mileage sufficient to penetrate the earth to China and back again to about the center of the globe.

A special dispatch from Leghorn, Italy, brings the news of a rich iron-ore strike in the region of Tambura Pass, which divides the provinces of Massa and Lucca. It is estimated that the deposits are capable of yielding more than 300 tons of iron a day.

The Throndon sea wall, at Wellington, the largest thing of its kind in New Zealand, is nearing completion. It will provide berthing facilities, three-quarters of a mile long, for ocean-going ships.

What is said to be the largest refrigerating plant in the world recently opened its doors to business in Buenos Aires. It is capable of handling daily 5,000 head of cattle and 10,000 sheep.

The United States is the world's largest producer of salt. The 1925 output amounted to 6,604,900 long tons, valued at $26,162,361, or about 30 per cent. of the total world production.

On the Buenos Aires Great Southern Railway, 53 per cent. of the fuel consumed is oil, 46 per cent. is coal, and the remaining 1 per cent. is wood, which is used for starting up.

The world production of artificial silk for 1926 is estimated at 333,000,000 pounds. The United States is in the lead, with a total output of 80,000,000 pounds.

The Badische Company, of Germany, is producing daily about 2,500 tons of ammonium sulphate from the sulphur content of gypsum.

Plans have been completed for the construction of an underground-railway system in the City of Buenos Aires.

The largest and richest known deposit of mercury is at Almaden, in central Spain. This deposit has been worked almost continuously since Roman times, and has been owned and operated by the Spanish Government since 1645. The ore bodies are large, some of them attaining 36 feet in width and as much as 600 feet in length. The mine has been developed to a depth of more than 2,000 feet; and the available reserve has been conservatively estimated at 44,000 tons of metal.

Singapore, located as it is in the center of a region which is now producing half the world's tin and 70 per cent. of the crude rubber, is fast becoming one of the greatest cities of the Far East.

A very ambitious scheme is on foot for exploiting the energy of the waters of the Danube, near Vienna, through the building of a 25-mile canal. It is said that 130,000 H.P. could thus be developed; and that the canal would also solve the much-debated and serious problem of flood control.

Owing to the increased demand for electric power, the Tasmanian Government is planning to double its output of hydro-electric energy by the erection of a new power plant on the Shannon River Lake. This is one of the largest catchment basins in Australia, holding more than 300,000,000,000 gallons of water. The work is to be completed in 1928, and at an estimated cost of about $1,000,000.

An extensive program of railroad electrification has been made public by the chief of the electrical bureau of the Railway Office of Japan. Work on the Otsu-Akashi and the Kozu-Numadzu lines is to be begun in 1929. But in order to meet the requirements for electrification in the Kwanto section, in the northern part of the main island, it will first be necessary to construct five power houses. One of these, to be built at Shimanogawa, will be outstanding in size and will involve an expenditure estimated at more than $18,000,000.

A great impetus has been given to silk culture in Spain because of a royal decree ordering both advisory and financial aid to the industry. As a result of this nation-wide effort to revive an industry that once flourished in that country, Spain again bids fair to become a potent influence in the world of silk.

The longest paved motor road in the world is the Pacific Highway from Vancouver, B. C., along the Pacific coast, to the Mexican border—a distance of 1,476 miles.

Switzerland serves 97 per cent. of her population with electricity from her water-power resources.

It is estimated that 40 per cent. of the German merchant marine is now motor driven, as against 15 per cent. before the World War.